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THE MONT CENIS TUNNEL.

(*Continued from page 229.*)

GENERAL DESCRIPTION OF THE WORKSHOPS AND WATER SUPPLY.

The ground lying between the torrent of Rochemolles and the village of that name, being on a slight and regular incline, was chosen as the site for the principal workshops, including the repair shops, the buildings for the air compressors, the dwelling-houses for the engineer, clerks, workmen, etc. In order to secure good communication between these large workshops and the head of the tunnel, a road was built along the side of the Rochemolles torrent 6,400 ft. in length. In front of the head of the tunnel, on the top of an embankment, mostly composed of rock excavated from the workings, smaller shops were established for those purposes which more closely appertained to the actual work of excavation, such as sheds for mortar mills, carpenters' shops, and repair shops, for making small alterations, and for doing general jobs to the boring machines, smiths' forges, etc.

At the commencement of the excavation, brick-yards were also established; but they were afterwards abandoned, the bricks being provided by contract, and transported from Oulx, where they were manufactured.

On the road leading to these secondary shops, and at some distance from any habitation, was located the chief powder magazine, which contained usually more than 25,000 lbs. of powder, and from which, for the sake of safety, the necessary supplies for 2 or 3 days were periodically removed, and placed under a shed not very far from the opening of the tunnel, near the shops where the mining cartridges were fabricated. The number of workmen employed in these establishments varied a good deal, the numbers being greater or less, according to the speed with which the excavation proceeded. But the average number engaged in the shops and in the tunnel was 1,500, besides 300 more employed in getting stone from the adjacent quarries, and some 200 bricklayers employed by private contractors, so that, in all, the number of men employed in and about the works at the Italian end was about 2,000, not inclusive of those engaged upon transport.

The workmen within the tunnel worked in 8 hour shifts, and thus 3 times in every 24 hours, that is to say, at midnight, at 8 A. M., and at 4 P. M., they were changed; those, on the contrary, working at the headings had no fixed hours, only changing when each set of men had finished their task of longer or shorter duration, according to the difficulties encountered; the workmen in the shop made on the average 10 hours' work daily.

The water used for driving the different machines was brought from the torrent of Meleget, near the village of Les Armand, along a fine aqueduct in cut

stone, and thence, through a system of sluices, it passed into the channel, conveying it to the shop. This channel is built in brickwork, and averages 3 ft. 11 in. in breadth, having a capacity of a cube metre per metre of length ; it is covered in some places with a brick arch, in others with stone flags ; for some distance it skirts the torrent, then turns, and follows the side of the mountains, underneath various torrents, until it crosses the Merdoune, by means of an aqueduct, after a course of nearly 2 miles. The waters of the Meleget, after heavy rain and thaws, are sometimes very muddy, and full of sticks and leaves, small roots, straw, and other debris, that would interfere with the action of the compressors first employed ; in order to prevent any serious inconvenience a large settling reservoir was made near Bardonnèche, and about $\frac{2}{3}$ of the distance from the commencement of the conduit. The water rushing into this reservoir with a great rapidity, attained by the fall of the channel, spread itself, losing its velocity instantly, depositing at the bottom the substance of the greatest specific gravity, whilst the lighter ones, floating onwards, were stopped at the outfall of the reservoir by movable gratings.

THE VARIOUS BUILDINGS AND THEIR USES.

On entering the principal yard of the Bardonnèche road, one sees on the right hand a plain building containing the offices. Near this is the mouth of the tunnel, which is made to connect the great tunnel with the Bussoleno-Bardonnèche line. The length of this connecting tunnel is 820 ft. Opposite the offices stand the dwelling-houses of the employés, and contain a club. Behind it are the wooden store shed, washing house, and infirmary, and not far off are small gas works, and a gas holder standing within a close circular shed. These works, which now only supply gas for lighting up different parts of the yard, were at first intended to make the gas with which it was proposed to light the interior of the tunnel as the work proceeded ; but this was found to be attended with great inconvenience, for when blasts were made, the expansion of the air extinguished the gas, and the workmen very often found themselves in perfect darkness, which, besides causing confusion and loss of time, permitted the free escape of gas which further vitiated the air, impure already from the explosion of the powder, and the exhalations of the workmen.

Along the banks of the torrent of Rochemolles are the dwelling-houses of the workmen, which are protected against floods by an embankment formed with the rock excavated from the tunnel. The unmarried men had 1 room awarded to 4, the married men lived in separate houses, and each having a room. In the centre of the yard is a spacious court, round which are ranged the repair shops, the compressor buildings, and a school-house for the workmen's children, and containing the apartments of the masters and mistresses, and a provision store. Opposite this building are two large reservoirs for compressed air, the use of which will be explained hereafter.

The shops for repairing the boring tools, and other machinery, contain every necessary for the purpose, such as lathes, planing machines, drilling machines, shaping machines, etc., besides the smiths' forges and air-driven hammers. The whole of the machinery with this last exception is driven by a 12-horse power wheel. A shop thoroughly well suited for these repairs was absolutely necessary in order that the constantly recurring alterations and repairs required by the perforators, should be done without any delay. The rapid destruction of their tools was due principally to the injurious action of the quartz dust, cut away by them, but also by the violent shocks which they constantly received when at work.

Near the repair shops, and occupying one side of the court-yard, are the compressor houses. The one first completed, containing the water column compressor, is a large covered building, with large windows, and enclosing 10 of these important machines, which, however, were, after a short trial, abandoned. Nevertheless, they are worthy of description, for the first led to the idea of mechanical perforation, which has been attended with so abundant a success. As regards these compressors, we must note that the different heights hereafter mentioned, refer to a horizontal plane, which we will call the effluent level, because it contains that height at which the water stands in

the compression chamber when it is full of the air that is to receive the descending stroke of the compressing column.

If we suppose the spectator standing on this plane, opposite to the compressor buildings on the right and left, he will see before him 10 compressors, all of equal dimensions, and divided into 2 groups of 5 each; between the 2 groups are 2 motors, actuated by the compressed air, each of which works a horizontal rod, opening and closing at regular intervals the supply and exhaust valves of the compressors. We may call this the principal valve motion. Each group of compressors is independent of the other, and has its motor and principal valve motion, but by a very simple arrangement both groups may be worked together, while, if when they are at work it happens that some of them may become impaired, they may be isolated without interfering with the rest.

For the special class of work to which they were adapted these precautions were absolutely necessary, so that under any circumstances a sufficient quantity of air may be secured in order to prevent any stoppage in the boring operations. In front of each of the compressors there is placed an iron receiver with spherical ends, into which the compressed air is delivered at every stroke of the same column of water that affects the compression. These receivers are made abundantly strong. They are all placed in communication with each other by means of a pipe, so that they all operate together, if desired, but may by divided into groups of any number, as may be expedient. By this arrangement the amount of power can be regulated, and repairs effected without causing any delay. The contents of each of the receivers is 600 cubic ft., and in order to ascertain exactly the quantity of air produced or consumed, each receiver was tested by fixed quantities of water being poured in, and the heights of the corresponding levels were marked on a scale outside; in this way the graduations to 3.5 cubic ft. were fixed. At 85 ft. 3 in. above the efflux level is the great reservoir, in which the compressing columns unite. These 85 ft. 3 in. mark the height or stroke of the column of compression so soon as it begins to come into action. Inside the reservoir the columns are made with a funnel-shaped top, so as to avoid the effects of the contraction of the water in its flow, and each is provided with a cover, so that the water can be excluded, and the corresponding compressor emptied, and submitted to repairs when desired. The water is led into the reservoir by large iron mains, which lead it from the conduit 65 ft. 7 in. above. These mains are, of course, fitted with all the necessary valves, sluices, etc., for keeping the water under control. At a point still more elevated, 164 ft. above the plane of efflux, on the hill side, is the regulating reservoir, having a capacity equal to upwards of 14,000 cubic ft., built in brickwork, and roofed over, the covering being supported on pillars, and earth being placed above for a depth of 3 ft. 3 in. to protect the water from the action of frost. From this reservoir two iron pipes are taken, each communicating with one of the 2 groups of receivers before mentioned, both groups being connected to the pipe that draws water from the regulating reservoir, and the columns of water contained in these pipes for their height of 164 ft. maintain almost invariably the pressure of air on the receivers. As regards the regulating columns, the receivers are put in action by means of appropriate valves, together or separately, so that in this detail also they work together or separately, as may be desired.

It was soon found, however, that these compressors became damaged by the violent shocks the valve had to resist, when they were suddenly closed, and hence their use has been abandoned; the simple machines known as the "water-spout" compressors, were found to be more reliable, so that all the compressed air has been produced by these machines. The water-spout compressors at work in the yard are actuated by 7 water-wheels; the quantity of water used is small, only 35.317 cubic ft. per second, but it has a considerable fall of 144 ft. The wheels were placed one below the other, so that the waste canal of one forms the supply canal of the other, and thus all the fall was utilized by giving 19 ft. 8 in. of fall to each wheel. The wheels are placed in separate buildings; the 3 lower ones are arranged back to back. A description of one will suffice for all. An iron wheel, 19

ft. 8 in. in diameter and 16 ft. 4 in. wide, gives motion from the shaft on which it is mounted to 2 heavy connecting rods, actuating 2 pistons. On each side of the wheel, stand coupled together 2 large cast-iron cylinders, vertical, but turned round at right angles at the floor level so as to form horizontal cylinders in which the pistons before mentioned work slowly, their alternate motion being communicated to a water column, which, rising and falling alternately in the vertical part of the cylinders, compresses the air which is admitted into, and forced from, the cylinder by means of a set of ordinary inlet and outlet valves.

An iron staircase leads to a gallery from which the upper part of the machinery may be examined. Everything works with the utmost precision, the motion is perfectly regular and free from shock, so that these machines work constantly for years without requiring repairs. The compressed air is passed into the receivers before mentioned, by a collecting pipe communicating with all the compressors. Up to 1864 these receivers were the only reservoirs for the compressed air, but they were insufficient for the quantity required, especially when any short delay took place in maintaining the supply. It became necessary, therefore, to construct other reservoirs, and 2 wrought-iron receivers, 164 ft. long and 6 ft. 6 in. diameter, were made, and now stand under the school-house and provision store.

When these were made, the regulating reservoir became insufficient, and therefore it would have been necessary to construct a much larger one ; but this great expense was avoided by regulating the pressure in the following manner : The consumption of the compressed air, or the working of the perforators, was intermittent ; during the time of work the consumption was equal to the quantity produced, but in the time of stoppages, the air passed from the compressors into the reservoir, and increased the pressure in them ; when this reached 6 atmospheres, a safety valve in the main that carried the air along the tunnel, opened, and the air that escaped through it was carried by a tube to ventilate the farthest headings ; and this was a very necessary precaution, because, when the mines were exploded, the dense smoke caused by the combustion of the powder rendered the workings untenable. So soon as the boring machines were put into work again, the pressure of course fell, and the safety valve closed. In this manner the pressure was regulated well, and with economy.

The large main that conducted the compressed air to the extreme limits of the heading, was laid along the road, resting on brick pillars, for a length of 6,400 ft., to the opening of the tunnel. This main was exposed to all the inclemency of the climate of Bardonnèche, and to variations of temperature ranging from 15 deg. of frost to 140 deg. in the sun. But these violent extremes had no serious effect upon it, although during winter a part of the main was always covered with snow. The tube is 7.84 in. inside diameter, it is .39 in. thick, and is made in lengths of 6 to 8 ft. These were cast with special care, and the joints are made good with compressed gutta-percha.

We may now say a few words about the shops at the entrance of the tunnel. Here are located the forges for repairing and sharpening the boring tools, the blast being obtained from a fan worked by a 10-horse water wheel. There are also workshops to repair the less important damages sustained by the drills, and which saved the trouble of their being removed to the main shops already described. Here, also, is a dwelling-house for the mechanics. Further on is an observatory—a small hexagonal tower, marking the line which passes through the centre of the tunnel, in the centre of which, and standing on a strong foundation, is a theodolite. At the entrance of the yard is the clerk's house, with the offices, and provision stores, general stores, stables, etc. A long shed serves for the carpenters' shops, and wagon shelters.

The mortar mills are also here, and near them a small machine for making clay tamps for the blasts ; the clay is forced through orifices of the desired size, and is cut off into lengths with wires, and dried. A large ventilator placed over the tunnel entrance drew through a wooden conduit, fixed to the roof of the excavation, the external air replacing it as it was exhausted. This fan was driven by the same wheel that

actuated the forge fan; it moved in a horizontal plane, was 19 ft. 8 in. in diameter, and was enclosed within a covered shed.

Originally the draught was produced by heated air from an upcast shaft, and though this arrangement answered when the borings had reached no great depth, it became of course entirely inefficient as the work advanced.

THE HEAT-RESTORING GAS-FURNACE.

From "The Mining Journal."

The importance of economizing fuel in the manufacture of iron, to enable us successfully to compete with foreign countries, can scarcely be over-estimated, and, in connection with the production of the finished metal, Gorman's heat-restoring furnace and Siemens' regenerative furnace have each proved to be of enormous value. In a paper read before the Institution of Engineers in Scotland, Mr. Gorman remarked that, when it is considered that a ton of iron at the welding point contains only the amount of heat which is due to about 56 lbs. of coal, and that usually 20 times this quantity is employed, it will appear that there is much room and much need for improvement in this department. The heat-restoring gas-furnace is designed to economize fuel by restoring part of the heat which escapes in ordinary furnaces, and it so happens that the arrangements necessary for this purpose are also admirably adapted for consuming the volatile gases of coal, thereby increasing economy and preventing smoke. It has been successfully applied in manufacturing iron, re-heating for plate and bar mills, puddling, welding scrap, etc. In the ship-builders' yard—forging and working plates, long angles, bars, etc.; it is also in use for boiler-makers, bridge builders, rivet and nail makers, and for enamelling and annealing, and has been so often erected in the neighborhood of Glasgow that only a very short description of it will be necessary. It is heated by combustible gases, which may be supplied from any suitable source, but have hitherto been supplied from the ordinary coal or slack procured in the neighborhood, and produced in apparatus attached to the furnace.

The gas used for illuminating towns, and the gases escaping from blast-furnaces may also be used effectively and economically for supplying the requisite heat, so that it is not essentially necessary that the gas should be produced in connection with this furnace. The furnace, with its gas-producer and heat-restorer, occupies about the same space, and is arranged and worked in the same way as an ordinary heating or puddling furnace, when applied to the same purpose; and, in addition to the usual damper, it has valves for regulating, admitting, or shutting off the air supplied for combustion as required. The gas producer occupies the same place as the grate room in ordinary furnaces, and only differs in being deeper, so as to allow, at all times, a thickness of over 2 ft. of fuel on the grate bars; this provision is necessary to prevent carbonic acid gas from rising amongst the combustible gases, the presence of which, even in small quantities, prevents the combustion of the volatile gases of coal, and is in all cases deleterious, and cannot be too carefully guarded against. Although the difference between the gas-producer and the fire of the common furnace appears very little, yet it is very great, and it is most important that it should be understood and properly worked, or the furnace will not heat well or give its highest results. All that is required is to keep the bars clean, taking out clinkers only, but no coke or charred coal can be avoided; fire often, and keep the fuel up level with the firing door, or higher, at all times, and not to put much on at a time.

When the gas from the coal leaves the producer, carrying with it the heat generated there, it is supplied at the bridge with air, in the proportion of about 12 times the weight of the fuel. The more heat which can be imparted to the air supplied for combustion, the less coal is required to maintain a given temperature in the furnace. The question becomes then—What is the best practical method of transferring the greatest amount of

heat from the highly-heated waste products, leaving a furnace to the air entering a furnace for combustion? The apparatus employed for this purpose is called a heat-restorer; it is based on a very elegant instrument for transferring heat, and which consists of 2 tubes, 1 placed within the other, the inlet of 1 tube adjoining the outlet of the other. The tubes are open at both ends. If hot water be poured into 1 tube and cold water in the other, the hot water will run out cold, and the cold water will leave the instrument heated very nearly to the temperature of the water which was poured in hot. The waste heat is transferred to the air for combustion by the restorer, in the same manner. The restorer is a chamber placed usually underneath the ground line, into which is placed a number of fire-clay pipes open at each end. A wall runs up at each end of the pipes, dividing the chamber into 3 compartments, 1 large in the centre, and 1 at each end of the pipes into which they open, connecting the smaller end chambers. The flame, or waste heat from the furnace, passes downwards through the centre compartment, impinging on the outside of the tubes placed therein. The air for combustion enters the end space at the bottom, passes through the pipes to the other end, rising to a higher series of tubes, and re-crossing till it arrives at the top of the chamber; the effect being an upward current of air meeting a downward current of heated gases, with only the thickness of the fire-clay tube between them; the current of air inside preventing the destruction of the tube by the high temperature outside. The only extra about this furnace, which has no counterpart in the common furnace, is the restorer, and in practice it gives no trouble. A set of restorer tubes has been worked regularly for 2 years, and when taken out for repairs, more than ½ were fit for use again.

With a view to ascertain the relative merits of the common furnace and the Gorman furnace, several series of experiments have been made. Five piles, each 470 lbs. = 2,350 lbs. were weighed and charged into the gas-furnace; the result was a yield of 2,247 lbs. of rolled iron, being a loss of 103 lbs., or 4.38 per cent. of the iron charged. At the same time the same number of piles of equal weight were charged into an ordinary furnace; the result was 2,058 lbs. of rolled iron, being a loss of 292 lbs., or 12½ per cent. nearly, of the iron charged, so that in the gas-furnace 1 cwt. 3 qrs. 19 lbs. less iron is used to produce a ton of rolled iron than with the ordinary furnace. These results were confirmed by subsequent trials; the returns of each are within a fraction of the above statements. A more extended series of trials was made by the Mossend Iron Company, to compare the waste of iron in the heat-restoring furnace, and that of the common furnace; 7 heats were charged into the common furnace, and 7 exactly similar heats into the gas-furnace; the result showed a saving in iron by the gas-furnace of 3 qrs. 19 lbs. per ton of iron produced, including croppings; but the saving is higher when estimated on finished iron, as of course it must be, to get a commercial result. Now, in producing 16 tons of finished iron, 20 tons of iron require to be heated, and when the loss on 20 tons charged is estimated on 16 tons finished iron in each case, the saving of the gas-furnace in the above instance is 1 cwt. 7 lbs. per ton of finished iron. The next comparative trials were made at the works of the Lancefield Forge Company. There were two gas-furnaces erected there, and from various causes they were not worked to a successful issue, and finally abandoned, to the loss of the firm, and of the inventor of the furnace. One of the furnaces did not work properly; in the other furnace, five days' trial, producing welded iron from scrap, showed 1 cwt. 1 qr. 7 lbs. less waste per ton of iron when it was welded in the gas-furnace. The next trials for comparing the common and gas-furnaces were made by Messrs. Colville & Gray, Coatbridge, who weighed the materials during a week's work of the gas-furnace and 2 common furnaces. There was a saving in this instance, in iron, 1¼ cwt. at 5s. = 6s. 3d.; and in fuel, 5s.; in all 11s. 3d. per ton of puddled iron. At this time the workmen stated that they would as soon work the gas as the common furnace. Further trials of a gas-furnace for welding scrap were made by Messrs. Gray & Wylie, Coatbridge, and they mention in their note that "the scrap used in these trials was all old scrap from a broker's yard; had we used new scrap of our own make, the waste would have been much

less. It will be observed that triping coal was used in the heats; we are in the habit of using dross, but in this instance were disappointed in getting it in; we find dross does the work equally well, and takes very little more weight than shown."

Referring to the advantages of the new furnace, Mr. Gorman points out that the gas-furnace is more easily kept in repair, and that it will do a third more work, with about ½ the weight of dross that is required in coal with the common furnace; but the peculiar feature of the gas-furnace is the non-oxidizing quality of the flame compared with that of the common furnace. When iron is welded in the flame of the common furnace, it is more or less oxidized or burned, depending on the amount of surface exposed, and when iron is thus heated its strength and tenacity are seriously impaired, and when it is overheated in the common furnace it is simply "burned," and any means by which such a contingency can be prevented or ameliorated ought to be adopted, more particularly in forgings, on the strength and tenacity of which depends human life, and it will materially add to our economical resources, when the engineer can depend on the intrinsic quality of his material, and not be compelled to resort to mere bulk and weight for safety. Mr. Gorman further maintains that when iron has parted with the most of its impurities, it is then in the most critical condition for being oxidized or burned. While impurities are present, they, to a certain extent, by their oxidation, save the iron; but, afterwards, each time it is heated in the common furnace it is exposed to free oxygen, and consequently loses its substance, strength, and tenacity, till at last it arrives at its normal state of an oxide or ironstone, and this is not a remote contingency, as a ton of scrap iron heated 6 times in the common furnace oxidizes a ton of iron to cinder.

Mr. Gorman has introduced a new form of puddling-furnace, which has undergone several modifications in accommodation to circumstances. There was no difficulty in obtaining heat, but puddling is not a mere question of heat; and after many trials, the existing arrangement is believed to be adapted to all the conditions necessary in the puddling process. Many very favorable results have been obtained from trials of former modifications. The flame travels all round the furnace, and escapes at a port adjoining that where it enters the furnace; thence it passes under an oven or retort in which the coal is placed, so that the waste heat is caused to coke the coal previous to passing to the restorer, thereby producing a hotter and purer gas, and at less expense of coal. By this means the flame is also cooled a little, so that it is not so severe on the tubes as it was found to be when passing direct from the puddling chamber of the furnace. It will be observed that the tubes are placed behind the furnace in this instance. This was found necessary in order to allow the furnace to cool quicker for fettling, and to keep the puddling stance cooler. The method of returning the flame in the furnace was modified from an arrangement in which the flame was caused to circulate in vertical planes, the flame passing out of the back of the furnace. It is named the "whirl flame" furnace, from the action of the flame. It is worked with dross; a saving in fuel of 10 cwt. per ton of puddled iron, and a saving in the yield of iron of at least a ½ cwt. to the ton, have been obtained at the Clydesdale Iron Works, Holytown, where 12 puddling furnaces are working on this plan. The method of returning the flame now adopted in the puddling furnace has been found to heat a third more iron with 15 cwt. dross per day, than was done formerly by a common furnace with 28 cwt. splint coal; the repairs are reduced by one-half. The puddling furnace is now being rapidly developed; and there is no doubt, he thinks, as to its realizing as large an economy as the heating furnace, the effect of which will reduce the price of making malleable iron about 20s. per ton.

In the discussion which followed the reading of the paper, it was elicited that Gorman's furnace is simpler in arrangement than Siemens', which is on the same principle as Stirling's regenerator. In reply to Mr. Kay, it was stated by Mr. Gorman that they preferred to use the blast where it could be got, and that there was no chance of dangerous explosion; he had seen some furnaces explode, but not after they had got into use, and only a few bricks had been displaced. He was engaged in applying the principle to smelting, and also to smiths' and founders'

furnaces. The President (Mr. David Rowan) remarked that there were other competing furnaces, such as Siemens' and others, all brought forward as saving iron and coal, but this furnace seemed to have another advantage—to be able to use triping and dross instead of splint coal; he had no doubt that this system of furnace might come into use for other purposes. Mr. Gorman had patented improvements in furnaces in 1852, and shown how gas was produced and used in furnaces in 1858, before Siemens brought out his gas-furnace. He intended to put up furnaces to work with half the coal used by Siemens' furnace, but the consumption of fuel by those furnaces was kept in the background. But, taking such data as he had been able to get, the fuel was 6.6 cwt. per ton of iron heated; in his own case, it was as low as 3.4 or 3.5 cwt. The economy from Mr. Siemens' furnace should be greater than what is obtained, and he accounted for the defect partly from it requiring to be of the same shape at the inlet and the outlet, to allow of the reversing of the currents—conditions which would cause great waste of fuel in other furnaces, and would also act in the same way against the Siemens furnace. The low temperature at which the gases escape from the Siemens furnace is referred to as an evidence that the heat is all used, but, as stated formerly, the heat contained in a ton of iron at the welding point amounts only to what can be obtained from about 56 lbs. of carbon, and as fully 12 times that amount is used in his furnace, $\frac{11}{12}$ of the heat should escape. The largeness of the structures would account for part of the loss of heat, but not sufficiently for the low temperature obtained, but the great loss of heat may be referred to another cause. It is a well-known fact that when the volatile gases from coal are heated above redness they are decomposed and their carbon deposited; now, it follows that when such gases are passed through the regenerator of Siemens' furnace the carbon will be deposited on the hot bricks, and will not reach the working chamber of the furnace, which is thus deprived of the heat from $\frac{3}{5}$ of the most valuable part of the coal. When the currents are reversed, this carbon will necessarily unite with the escaping flame to produce carbonic oxide gas, which is colorless, and lowers its temperature 60 per cent., and at the same time carries a great part of the fuel up the chimney, thus having an appearance of great economy, while there is actually great waste going on. Parties conversant with those subjects will understand this at once, but, as a practical proof, he might mention that while the hand may be held in the gases escaping from the Siemens furnace, those from the heat-restoring furnace will melt brass, even while working to a much higher economy than he had heard recorded of the Siemens furnace.

ON THE GASEOUS AND LIQUID STATES OF MATTER.

From "Nature."

A discourse was delivered on Friday evening, June 2d, at the Royal Institution in Albemarle street, by Dr. Andrews, on the "Gaseous and Liquid States of Matter," from which we make the following extracts:—"The liquid state of matter forms a link between the solid and gaseous states. This link is, however, often suppressed, and the solid passes directly into gaseous or vaporous form. In the intense cold of an arctic winter, hard ice will gradually change into transparent vapor without previously assuming the form of water. Carbonic acid snow passes rapidly into gas when exposed to the air, and can with difficulty be liquefied in open tubes. Its boiling point, as Faraday has shown, presents the apparent anomaly of being lower in the thermometric scale than its melting point—a statement less paradoxical than it may at first appear, if we remember that water can exist as vapor at temperatures far lower than those at which it can exist as liquid. Whether the transition be directly from solid to gaseous, or from solid to liquid and from liquid to gaseous, a marked change of physical properties occurs at each step or break, and heat is absorbed, as was proved long ago by Black, without producing elevation of temperature. Many solids and liquids will for this reason

maintain a low temperature, even when surrounded by a white hot atmosphere, and the remarkable experiment of solidifying water and even mercury on a red hot plate, finds thus an easy explanation. The term spheroidal state, when applied to water floating on a cushion of vapor over a red hot plate, is, however, apt to mislead. The water is not here in any peculiar state. It is simply water evaporating rapidly at a few degrees below its boiling point, and all its properties, even those of capillarity, are the properties of ordinary water at 96.5 deg. C. The interesting phenomena exhibited

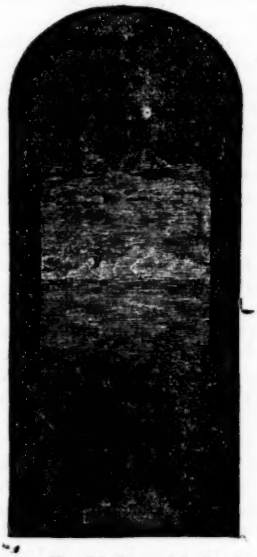


FIG. 1.—Cloud below critical point.

under these conditions are due to other causes, and not to any new or peculiar state of the liquid itself. The fine researches of Dalton upon vapors, and the memorable discovery by Faraday of the liquefaction of gases by pressure alone, finished the work which Black had begun. Our knowledge of the conditions under which matter passes abruptly from the gaseous to the liquid and from the liquid to the solid state, may now be regarded as almost complete.

"In 1822 Cagniard de la Tour made some remarkable experiments, which still bear his name, and which may be regarded as the starting point of the investigations which form the chief subject of this address. Cagniard de la Tour's first experiments were made in a small Papin's digester, constructed from the thick end of a gun barrel, into which he introduced a little alcohol and also a small quartz ball, and firmly closed the whole. On heating the gun barrel with its contents over an open fire, and observing from time to time the sound produced by the ball when the apparatus was shaken, he inferred that after a certain temperature was attained the liquid had disappeared. He afterwards succeeded in repeating the experiment in glass tubes, and arrived at

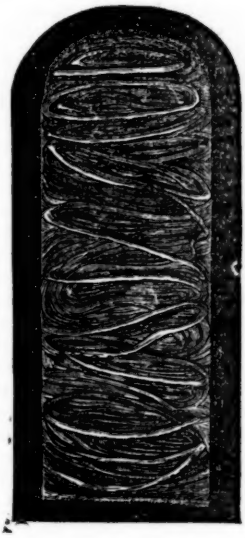


FIG. 2.—Striæ above critical point.

the following results: An hermetically sealed glass tube, containing sufficient alcohol to occupy $\frac{2}{3}$ of its capacity, was gradually heated, when the liquid was seen to dilate, and its mobility at the same time to become gradually greater. After attaining to nearly twice its original volume, the liquid completely disappeared, and was converted into a vapor so transparent that the tube appeared to be quite empty. On allowing the tube to cool, a very thick cloud was formed, after which the liquid reappeared in its former state.

"It is singular that in this otherwise accurate description Cagniard de la Tour

should have overlooked the most remarkable phenomenon of all—the moving or flickering striæ which fill the tube, when, after heating it above the *critical point*, the temperature is quickly lowered. This phenomenon was first observed by the lecturer in 1863, when experimenting with carbonic acid, and may be admirably seen by heating such liquids as ether or sulphurous acid in hermetically sealed tubes, of which, when cold, they occupy about $\frac{1}{3}$ of the capacity. The appearances exhibited by the ascending and descending sheets of matter of unequal density are most remarkable, but it is difficult to give an adequate description of them in words or even to delineate them.

"These striæ arise from the great changes of density which slight variations of temperature or pressure produce when liquids are heated in a confined space above the critical point already referred to; but they are not formed if the temperature and pressure are kept steady. When seen they are always a proof that the matter in the tube is homogeneous, and that we have not liquid and gas in presence of one another. They are, in short, an extraordinary development of the movements observed in ordinary liquids and gases when heated from below. The fact that at a temperature of 0.2 deg. above its critical point carbonic acid diminishes to $\frac{1}{3}$ its volume from an increase of only $\frac{1}{37}$ of the entire pressure, is sufficient to account for the marked characters they exhibit.

"If the temperature is allowed to fall a little below the critical point, the formation of cloud shows that we have now heterogeneous matter in the tube, minute drops of liquid in presence of a gas. From the midst of this cloud (as shown in Fig. 1) a faint surface of demarcation appears, constituting the boundary between liquid and gas, but at first wholly devoid of curvature. We must, however, take care not to suppose that a cloud necessarily precedes the formation of true liquid. If the pressure be sufficiently great, no cloud of any kind will form."

After describing the results obtained by the lecturer with carbonic acid under varied conditions of temperature and pressure, Dr. Andrews remarked that it would be erroneous to say that between liquid and gas there exists one intermediate state of matter, but that it is correct to say that between ordinary liquid and ordinary gas there is an infinite number of intermediate conditions of matter, establishing perfect continuity between the two states. Under great pressures the passage from the liquid to the gaseous state is effected on the application of heat without any break or breach of continuity. A solid model, constructed by Prof. J. Thomson, from the data furnished by the experiments of the lecturer, exhibited very clearly the different paths which connect the liquid and gaseous states, showing the ordinary passage by break from the liquid, as well as the continuous passage above the critical point.

After referring to the experiments of Frankland on the change produced by pressure in the spectrum of hydrogen, and to those of the same able chemist and Lockyer on the spectrum of the spark in compressed gases, Dr. Andrews described the remarkable change from a translucent to an opaque body, which occurs when bromine is heated above the critical point; and then drew attention to the general fact that when the critical point is reached, the density of the liquid and the gas becomes identical.

In order to establish the continuity of the solid and liquid states, it would be necessary in like manner, by the combined action of heat and pressure, to obtain the solid and liquid of the same density and of like physical properties. To accomplish this result would probably require pressures far beyond any which can be reached in transparent tubes, but future experiment may show that the solid and liquid can be made to approach to the required conditions.

The Select Committee on the disputed ground on the Thames Embankment met recently, the Chancellor of the Exchequer in the chair, and examined at considerable length Mr. Gore, one of the Commissioners of Woods and Forests. He stated that the lands reclaimed from the Thames in front of Whitehall Gardens to Whitehall Place not required for the Crown lessees, or for the purposes of the Embankment proper, was the absolute property of the Crown. He was cross-examined by Mr. Locke, who called upon him to prove the title of the Crown.

BOILER EXPLOSIONS.

By H. ASHTON RAMSEY.

In the early days of steam engineering, when boilers were designed to carry a pressure of only 15 lbs. of steam to the sq. in., explosions were of rare occurrence, and when they did occur, engineers invariably attributed these terrible calamities to one of two general causes: insufficiency in the strength of the boiler, or combined carelessness and ignorance on the part of the boiler attendant.

Deficiency in the strength of a boiler may be from one or more of four primary causes—inferior and defective material, indifferent workmanship, improper design, or from oxidization of the material, the latter occurring when the water used for the feed contains chemical impurities which have an affinity for the iron, or from age.

From ignorance and negligence explosions may be brought about in the following manner: (1) From permitting an excessive pressure to accumulate in the boiler, the steam being generated more rapidly than the safety-valve orifice will permit it to escape. (2) From allowing the water in the boiler to subside below the crown-sheet or flues, which being unprotected, and subjected to the intense heat of the furnace, burns, blisters, cracks, and finally gives way; or, when in this red hot state, to suddenly raise on it the water, already heated to a high temperature, which is effected by incautiously admitting feed-water, opening the throttle-valve wide, or suddenly raising the safety-valve, either of which acts, by relieving the pressure, would cause a violent ebullition of the water, which, coming in contact with the hot surfaces of the iron, would throw off steam more rapidly than it could be carried off either by the safety-valve or throttle-valve; hence an explosion is the immediate consequence, unless the boiler should possess extraordinary strength.

For many years the above-mentioned causes, seeming so clearly to exhaust the whole subject, were universally accepted by engineers. Of late years, however, since the introduction of high-pressure steam, of such an increased tension, that the word low-pressure, still applied to non-condensing engines, has become a misnomer, there have been such frequent explosions and collapses of boilers, where the newspaper statements of the attending circumstances at the time of, or just previous to, the explosion, could not be reconciled with the above views—for instance, stating that the boiler had been thoroughly constructed, the water had not been allowed to get low, and the pressure was no higher than usual, etc.—that engineers and others began to look around for other causes for boiler explosions, and many very remarkable theories were advanced to prove the causes of the "reputed fact" that boilers had exploded under the last-named condition of circumstances. Some attributed the phenomenon to the decomposition of water into its elements, whereby highly elastic gases would be evolved, which having the explosive force of gunpowder, no vessel however strong could contain it; others to some mysterious electrical agency existing among the molecules of steam, etc.

Now, I am far from being convinced that either of the last two mentioned causes ever had anything to do with the explosion of steam boilers, or that any boiler ever exploded that had been properly designed and constructed of good material, not corroded or weakened by age, or otherwise, and carefully managed by a man understanding his business; but even supposing the above theories do have some bearing on an occasional explosion, it appears to me the advancement of such theories, tending as they do to relieve both the boilermaker and the attendant from responsibility, is fraught with great danger.

Already many engineers in speaking of boiler explosions shake their heads, look very wise, and say they are attributed to some mysterious agencies not as yet thoroughly understood, and it has become quite popular to sneer at the previously established doctrines on the subject.

Recently the writer, on visiting the scene of a boiler explosion, which was doubtless caused from bad material used in the construction of the boiler, although the newspapers did not so report it, fragments were thrown several hundred feet from the previous location of the boiler.

An engineer remarking on the explosion, was heard to say "that the boiler must necessarily have been very strong to have allowed such an enormous force to accumulate in it." Now let us see how strong the boiler would have had to have been. The boiler was designed for a pair of high-pressure cylinders, and made to carry a working pressure of 75 lbs. to the sq. in., hence certainly should not have given way under a bursting pressure of 100 lbs. to the sq. in. Now, suppose the pressure was 100 lbs.—and it must be admitted that the boiler ought to have stood this pressure—what would be the effect of say a square foot of iron driven in the air by an initial force of 100 lbs. to the sq. in. $\frac{100 \times 144}{2240} = 6\frac{42}{100}$ tons to the sq. ft.? Is it at all wonderful that such a projectile should have the power to pierce through a shingle roof, kill a man standing near, or blow through the bottom of a boat, causing it to sink.

Persons passing near a boiler and looking up to the little index of the steam gauge, as it points around to the number of lbs. of pressure in the boiler, do not realize that they are in such close proximity to a pent up force, which, although very manageable as long as confined in a well-constructed boiler of good material, is liable at any time to burst forth and spread destruction around it, when the case is reversed and the boiler is weak and unfit for service. The reports of the inspecting engineers of the "Boiler Users' Associations" in England, and the Boiler Insurance Companies of this country, show how many boilers are allowed to be operated, when they have become more dangerous than so many powder magazines.

The great expense steam users have been put to in England, on account of lawsuits brought against them to recover damages for loss of life and property, caused by boiler explosions, has affected their prospects so severely that, from self-defence, they have formed themselves into associations, and appointed competent engineers to make periodical inspections of their boilers. From a recent report appearing in "Engineering," from one of these inspectors, out of a large number of explosions and collapses, extending over a long period, there was only one attributed to causes unknown; all the others could be traced directly to weakness in some part of the boiler, or carelessness on the part of the engineman.

In these days of strong competition among boiler builders, the temptation to use indifferent material and cheap labor is very great; therefore it is all-important that steam users should have their plans and specifications for boilers prepared by competent engineers, and have the work thoroughly inspected; also to be particular in employing none but competent attendants to take charge of their boilers, and the latter should be licensed by law, those having charge of boilers on land, as well as those on the water. In some States I believe this is already required.

By giving more attention to the construction and arrangement of steam boilers, were "steam-users" to follow the course indicated, explosions would be of rare occurrence, if not entirely prevented, and the proprietors would be large gainers pecuniarily; for the additional expense necessary to the employment, in the first place, of a competent mechanical engineer, to plan and superintend the construction of the boiler, and, secondly, the difference between the wages of an incompetent and a competent engine-man to manage it, would be insignificant compared with the great loss arising from the rapid deterioration and short life of an inferiorly constructed and badly managed boiler, to say nothing of the immense losses incurred in the case of explosions, followed by lawsuits, damages, etc.

Engineers themselves should be very slow to admit excuses for these terrible calamities; for, while we can fully recognize and appreciate the fact that steam boilers, when in use, always contain within themselves elements which, uncontrolled, would form a force sufficient to rend asunder the strongest vessel that could be fabricated, still, we also are as fully aware, that by properly regulating these elements, they are perfectly harmless and subservient to our will and purposes.

Many engineers on steamboats bestow all, or the greater part of their attention to their engines, leaving the boilers to the care of the firemen. I know the plea for this is, that they are required always to be convenient to the stopping and starting gear, so as to be able to obey sudden signals from the deck. Now, it would be

comparatively an easy matter to train an unlettered fireman to stop and start an engine, who could be left at the starting gear while the engineer made examinations of the conditions of his boiler. The latter being by far the most dangerous and important part of the mechanism under his control, and requiring all his intelligence and vigilance, and should therefore receive the greater part of his attention.

Daniel B. Martin, Esq., late Engineer in Chief of the Navy, recognized the importance of paying more attention to the boilers than had been the custom when he took charge of the machinery of one of the Collins steamers, which he operated with such signal success, distancing by far all his competitors and gaining the reputation the line earned of being then the fastest vessels on the ocean. He required his senior assistants to keep the boiler-room watch, and placed the juniors in the engine-room, which no doubt had a great deal to do with his unexampled success.

NARROW GAUGE RAILWAYS.

From "Engineering."

The first great revolution in railway practice is taking its successful course, not without strenuous opposition from prejudice, conservatism, and indifference; but all these obstacles and the difficulties they create directly and indirectly, are being swept away, as the conviction gathers strength that countries now unprovided or ill supplied with railways must soon have them, and that they must be productive, and not sources of loss. There is only one means by which this result can be achieved—a reduction of gauge, an increase of gradients and curves, cheap railways—in short, proper mechanical appliances for economically working traffic, and a rigid observance of economy in construction and in management. There are very few, even of those who have carefully followed the discussions upon narrow gauge railways in these columns and elsewhere, who have any idea of the extent to which such constructive reform has now spread. The situation may be summed up thus: In India a gauge of 3 ft. 3 in. has been established, upon a scale that will bring into existence a system probably of thousands of miles. The reduced width will, in fact, become the gauge of the country. Australia, Tasmania, and New Zealand are all following the same course. Australia especially is determined upon receiving the reform and carrying it out fully. In Russia the 3 ft. 6 in. gauge is definitely accepted, and the results of its working will shortly result in the construction of an enormous *réseau* of lines from north to south, from the Baltic, penetrating into Siberia. In Egypt the same width is to be adopted. In the United States more than 2,000 miles of narrow gauge line are in actual progress, or about to be commenced. California is organizing railways on the reduced gauge in all directions; lines are being started in the unsettled territories of the West and North-west, where communications alone are required to convert uninhabited regions to wealthy agricultural or rich mining districts; in the Eastern and the Central States, where energy and capital are most alive and plentiful, narrow gauge companies and organizations—not vague schemes, but promoted by engineers and capitalists—are urging the construction of independent railways, or of feeders to the existing lines. In Canada, where progress drags along most wearily, narrow gauge railways are being built; even for Prince Edward's Island contractors are at the present moment solicited to tender for the construction of a 3 ft. 6 in. line from Casumpec to Georgetown, a distance of 120 miles.

So gradually do even the most rapid changes and advancements take place around us, that it is difficult to comprehend that changes *are* taking place. For the past 12 months we have been living in history, the most stirring, wonderful history the civilized world has ever known yet; we cannot realize it; events must pass, must become contracted by the effect of distance, which gives bold outlines while it fades out details, before we can really understand what has had place. What is not palpable to the senses cannot take easily a defined position in the mind.

When railways superseded roads, and speed in travelling was quadrupled, and comfort and business facilities infinitely increased, there was produced a mighty change palpable to all, because the effects appealed to the senses; but it is impossible, at any special time, to realize the improvements that have been made from the days of the Manchester and Liverpool Railway to the present time, without taking a standpoint from which to review, consider, and compare all the changes and developments, each of which helped forward the end.

So now, although the establishment of a 3 ft. 6 in. gauge is the greatest change that has ever been made in railways, since railways were, it attracts but little attention save from those capitalists and engineers immediately within the circle; and when in the future there shall exist a system more extensive than that of the present standard and exceptional gauges combined, wonder will begin to arise as to the history of the great change, and to whom the reform was due.

We propose in this article to place on record the history of the narrow gauge movement, both for the information of the public at the present time, as well, and more particularly for future reference. And we consider this to be a special duty, not only because we have ourselves been almost uninterruptedly advocates of reduced gauge, but also because we consider that the real authors of the reform should receive their due acknowledgment, while we are convinced that unless such a record be made, it would not be long before a multiplicity of claimants would dispute for that which was not, and never had been, their own.

It is just 8 years since the Festiniog Railway, with a 2 ft. gauge, constructed in 1833 as a horse tramroad, was converted into a steam-worked railway for the conveyance of passengers, and of the slate quarried from the Festiniog hills, to be shipped at the quay of Portmadoc. This change of the horse-worked tram into a locomotive-worked railroad may be considered as one of the first steps towards the advancement at which we have arrived to-day. The Festiniog railway was not, it is true, the first steam-worked line of an exceptionally narrow gauge. Not to revert to the early days of tramways, there was the Broelthal Valley Railway, near Cologne, with its 2 ft. 7 in. gauge, already in operation. The Queensland line, 3 ft. 6 in. in breadth, had been surveyed, and practically adopted, based upon the experience obtained from a small railway of the same width in New Zealand. In Norway Mr. Carl Fihl was working out the problem that should give railways to an essentially poor country, in which English engineers had already proved the ordinary gauge to be commercially impossible by costly, even ruinous experiments.

But from English experience are obtained the data which govern colonial practice, and which guide Continental, and, especially American engineers; and, upon the Festiniog Railway the only available experience as to efficient working of narrow gauge railways was to be obtained in this country. But although it is 8 years since the change was first made upon that line, and although independent engineers have been independently working out the question of cheap railways, based on a reduction of gauge, ever since that time, it is only some 2 or 3 years since the great reform began to be seriously and systematically agitated.

It is worth while reviewing briefly the part that the Festiniog Railway has really played in the matter of this railway reform we are considering. But for the energy displayed in bringing the capabilities of that line prominently forward, and showing all that it could do with efficient mechanical appliances, there would have been no experience, only theory to guide, and the question of reduction of gauge in its general application would probably have been thrown back for another 10 years. So much has been talked and written about the Festiniog line, so much is it quoted everywhere, that the whilom slate tramway has been brought into a celebrity unsurpassed even by the Great Pacific Railroad; and it is this notoriety that leads many to unfavorable criticism, and to the publication of their opinions, that the railway has been simply used as an advertisement to further personal interests. It is urged among such that the traffic upon the line is small, that the freight is of the heaviest, most close-lying description, that all the gradients are in favor of the load, and that, under these circumstances, the duty it performs is simply proportioned to its size, whilst the

special class of engines running upon it have everything notoriously in their favor for the production of good results. By this, and similar specious arguments, a certain number of conservatives, or those impelled by actual personal motives, misrepresent the *rôle* of the Festiniog Railway, just as much as do some of those holding other views, who, led by their exuberance of feeling on seeing what can be effected on a gauge less than 2 ft. wide, run off straightway, and cry out for 2 ft. everywhere.

For its special duties the Festiniog Railway has an ample width; it has to convey but comparatively few passengers, and a considerable freight, measuring only some 15 ft. to the ton, which permits the rolling stock to be of the most simple description, so that the trucks upon which the slates are conveyed are small and low, while the passenger carriages are suited to the requirements of a somewhat primitive people. But for ordinary traffic, such a gauge would be utterly unfitted; the maximum width of vehicles that could be placed upon it would be insufficient for the purpose of general goods or passenger traffic, although ample engine power could be placed upon it to meet its utmost requirements. Thus both unreasoning and unreasonable advocates and opponents of narrow gauge, judge the Festiniog Railway in a false light, and fail to see that it was the only line in England upon which the problem could be worked out with anything like completeness, just as they fail to appreciate fully the importance of the results that have been obtained. It is true that all this time there existed a system of railways in Norway whose width had been carefully and judiciously selected with regard to the requirements of a general traffic, that there the question had been worked out thoroughly upon the most economical model. But except from the written and published data as to the performances and capacity of these lines written by their able engineer Mr. Pihl, those railways were unavailable for the advantages of experience. Add to this that the traffic returns in that country are too slight to afford any idea of the ultimate capacity of a narrow gauge railway, and that the engine power employed was proportioned to the traffic necessities, and it will be readily understood why it was impossible to obtain ultimate data. On the other hand, the Festiniog Railway lay close at hand, with its steep gradients running down towards its Portmadoc terminus, and its sharp curves, giving ample opportunity for conducting experiments inseparably connected with the subject. Moreover, the single element wanting had been supplied, thanks to the energy of Mr. Spooner, the superintendent of the line, and Fairlie engines were running on the road, and proving by their daily practice how large an amount of work could be done upon the tiny pair of rails with its heavy inclines and its narrow sweeps. Had the railway been 3 ft. 6 in. wide instead of a trifle less than 2 ft., half the ridiculous statements and assertions that have been made concerning it, and those connected with it, would probably have been spared.

Developed, then, as it had been by Mr. Spooner and Mr. Fairlie, the Festiniog Railway became a perfect experimental line, but nothing more. None of those connected with it have claimed more than this; it is only opposing argument and foolish advocacy that have endowed it with an undue importance. Nevertheless this little line was the cradle of the great enterprises now springing up on all sides. In 1869 the Russian Government, which had in some degree made itself acquainted with what had been done upon the railway, instructed the Minister of Public Works to invite Mr. Fairlie to visit St. Petersburg, to obtain information from him as to the capacity of his engines, and the experience which he had derived from the working of the Festiniog line. The result of this interview was the appointment by the Emperor of Russia of a Commission instructed to proceed to England, and investigate the truth of the favorable statements made in Mr. Fairlie's report. The Commission arrived here, as will be remembered, the president being the Count Alexis Bobrinsky, and the members various eminent Russian engineers, who, together with General Sir W. Baker, Captain Tyler, and others, visited the Festiniog Railway, and took much trouble to satisfy themselves, not only as to the truth of the statements which had been made to them, but also with regard to the relative efficiency for general traffic of cheap lines based upon the experience given by the Festiniog

Railway with its special duties. We need not refer now at any greater length to these proceedings; it is sufficient to remind our readers that, guided by what they had seen, fortified also with the experience of the 3 ft. 6 in. Norwegian system, the Russian Commission returned to St. Petersburg, and submitted such a report, that during the following May, after the matter had been discussed at a convocation of all the leading scientific men in Russia, the Emperor decreed the immediate construction of the Imperial Livny Railway with a 3 ft. 6 in. gauge, commencing at or near the Vierhovia station on the Orel and Eletz Railway, and terminating at Livny, a distance of 39 miles. The works were set in hand last summer, and completed the November following, despite the unusually inclement season of last winter. This railway was not, however, opened to the pub'ic till last March, owing to a delay in the delivery of the rolling stock and engines.

The energetic action taken by Russia in this question was due entirely to the experience obtained in Wales, and the same may be said with regard to the decision more recently made upon the future gauge for India; in consequence of the reports of Captain Tyler and those members of the Indian Council who accompanied the Russian Commission, the Secretary of State for India forwarded to that country the responsible statements which had been brought under his notice. The result of this action was, that another Commission was sent to Wales, consisting chiefly of the leading engineers and others connected with the Public Works Department in India—of the number we may mention Colonel Strachey, Colonel Dickens, Mr. Stanton, Mr. Luard, etc., besides Mr. Rendel and others. Here experiments similar to those which had convinced the Russian Commission were repeated, and the results with reference to the Indian engineers were much the same. Colonel Strachey, Colonel Dickens, and Mr. Rendel reported, as may be remembered, in favor of a gauge 2 ft. 9 in. wide, whilst Mr. John Fowler, taking up the question on a broader basis, in fact, the basis upon which we have always argued this question, came to the conclusion that the balance of advantages rested with a gauge 3 ft. 6 in. wide. The 3 first named gentlemen, however, who had been instructed to report, struck with the capability of the Festiniog Railway, expressed their conviction that a gauge but little exceeding 2 ft. would be sufficient for Indian requirements. But guided by mature consideration, they advised the adoption of 2 ft. 9 in. as the new Indian standard. Supreme decision alighted between these two recommendations, and established 3ft. 3 in. as the future Indian gauge. Indisputably this result was brought about by the previous action of the Russian Commission, and the facilities afforded by the Welsh line.

So far we have shown that in two vast countries where established gauges previously existed, and in one of which, at least, there flourished, directly and indirectly, in the shape of opposing acting resident engineers, and opposing consulting engineers at home, the most violent antagonism, the new system has taken a firm footing, and must without doubt be extended rapidly during the next few years.

We next pass to our remote colonies of Australia and New Zealand and to the United States. In the former, as we stated last week, the keenest agitation exists on the subject of narrow gauge railways, combined with the most earnest determination of overthrowing the existing practice, which has proved absolutely ruinous to the interest of the colonies. In a country of such vast distances as Australia, a country thinly settled, for the most part agricultural, where favorable localities are either widely separated from each other or from commercial centres, railway communication means life, the absence of it stagnation and paralysis. Yet it is as impossible in Australia, as it was proved to be in Norway, to construct the old types of railways. The English experience of to-day gives to the colonists that which they require, in exchange for the stereotyped practice of an antiquated professional generation. Here, again, Festiniog Railway experience has done its work so completely and satisfactorily that already the broad gauge engineers engaged in Australia must resign their posts, or fall in with the inevitable changes.

And if this determination be so conspicuous at the Antipodes, it is no less strongly marked in the United States. Already there exists there a railway system, for the most part of the ordinary

gauge, of many thousand miles; but this extent, vast as it is, covers but a small portion of the country with an effective network. In the Eastern and Central States, where great highroads of travel have been built—main lines and branch lines—the necessity of a sub-system is urgent. The State of Massachusetts is seeking to obtain a Bill authorizing the construction of narrow gauge roads, and its example will be followed by many other States. But in the western parts of the Union, not to speak of California, where the system is so thoroughly established that the present standard will soon become the exceptional gauge, the necessity for such roads is most keenly felt and most earnestly advocated. Vast tracts of land now lie idle, they require only occupiers to swell the revenue of the country. Such lands may be rich in timber, in soil, in pastures, in minerals, but, lying far removed from railway communication, they now form but so much fallow wealth. To unite such districts with the town centres, and the seaboard, to place them within the reach of colonization, and to enable them to obtain supplies, and to export their produce, in such a manner as would encourage emigration, can only be effected by the cheapest of cheap railways. It is no wonder, then, that the American engineer, seeing the practicability of such lines, hesitates but little in embarking wholesale into ventures that are sure of success. That they have not at an earlier date adopted narrow gauge railways to a large extent, may be explained by the fact, that in any radical change the American engineer looks to England for guidance, but having once seen a problem, whatever it may be, worked out, he puts it into rapid and extensive execution, whilst we, more soberly, are thinking of it.

We have thus sketched the history of narrow-gauge railway reform, a reform which, as it involves that evil so terrible to old-fashioned engineers—a break of gauge—has been, according to Mr. Bidder, "conceived in ignorance and maintained in folly," and we have seen how this same ignorance and folly, having infected the best engineers' brains in Russia, has spread to India, has become malignant in Australia, now rages in America, and that this radical epidemic has spread from the little spot in the Welsh hills. It remains to be seen who are the real agents in bringing about the change which is so largely superseding the empirical 4 ft. 8½ in. gauge, and has, to all intents and purposes, taken the place for future works of the uselessly extravagant 5 ft. 6 in. Indian gauge.

So quietly has Mr. Carl Pihl proceeded with his work of providing Norway with railways suitable to her means, that little or nothing would have become known to the public as to the doings of that able engineer but through the influence of this journal, and even after we had made known to every one that his system of narrow-gauge lines was perfectly successful, but few English engineers, and fewer continental ones, have had the opportunity, or taken the trouble, to avail themselves by personal observation of the experience there to be obtained.

On the other hand, the chiefs of the whole railway world are individually acquainted with Festiniog, and on that imperfect, because entirely special line, they have seen and been able to judge for themselves. But this new railway, for the purposes of estimation and comparison, would have been as useless in its early steam days as it was when horses toiled up and down its gradients with the slate trolleys, had not the special locomotive appliances, which have helped to make it celebrated, been added to it. It was the addition of those engines a few years ago that first brought Mr. Fairlie into connection with the railway, and gave him the occasion for learning the real capacity of a small line, as well as the full advantages of his system of engines. What the general advantages of these latter are we have too often and too fully considered, to repeat here; all that is necessary to say now is, that without them extremely narrow gauge railways cannot be efficiently worked, and no line can be worked up to its full capacity. Having by years of labor established the fundamental principles of his system, Mr. Fairlie commenced the work which is now so fully crowned with success. At public meetings, in private gatherings, before scientific societies, in the press at home and abroad, he labored to show the evils of the existing system, the possibility of an improved one. In one form or other he has continued this work for nearly 8 years, and his contributions to railway literature on this subject are now more

read, more considered, and more quoted than that of any other author or authors. By unceasing work against unceasing opposition he has fought almost unaided in the cause, and though he commanded a limited audience, and had brought over a few earnest thinkers, it was only after the visit of the Russian Commission that his success began. In that act he had done more unhelped than any combination could have hoped to do. A prophet is without honor in his own country, and in St. Petersburg he received the consideration and attention denied him here. The conclusions of so important a Commission stirred the Indian Government, and this time Mr. Fairlie, who had made the Festiniog line that which it is, obtained a partial hearing, his presence being necessary on the occasion of the inspection. That he was not consulted, after having been made use of, was unfortunate, but perhaps natural; but by this time the almost incredible quantity of essays, lectures, and information he had circulated abroad, began to take effect, and at the present time it is scarcely possible to read any newspaper published in Australia or the United States without a reference to himself or his work. In the latter country especially, beyond the information obtained from our columns relative to the Norwegian lines, his writings on the subject are quoted, to the exclusion of anything else. His advice is sought from almost every State in the Union, and to-day he is the one great English railway authority in America. The acknowledgment still withheld here is freely accorded to him on the other side of the Atlantic; it may be because American engineers hail with alacrity any one who points out new truth, and shows the way to progress; it may be because, in the United States, there exists none of that jealousy and mistrust towards a foreign engineer which, with some few exceptions, have been the sole recognitions accorded by English engineers to Mr. Fairlie in this country. In fact, it is scarcely too much to say that there are no narrow gauge undertakings incorporated in the States without his direct advice and assistance, whilst his views are accepted both in relation to his engines, and also to the special gauge of 3 ft., which he has made his own, and which is now well known as the "Fairlie gauge."

In Russia, the principles he has advocated have been entirely followed, with the exception that the width adopted is that of the Norwegian standard. In all other respects the Livny Railway is essentially a cheap line, with steep gradients and sharp curves. Upon it the Fairlie engines are at work, developing results which surpass the greatest expectations of the Russian engineers who recommended them, and who are unanimous in their opinion that to insure a complete railway success in this country the whole of the new network of lines must be worked by them. The soundness of the policy advocated by Mr. Fairlie will be further tested by a series of trials, made by an Imperial Commission, upon the result of which the full adoption of his engines for Russia will depend. These trials we shall shortly publish; meanwhile we may say that the experience already obtained has brought the matter to a foregone conclusion.

Thus in America, Russia, and Australia, we find that at present Mr. Fairlie meets with just appreciation, always excepting the babbling jealousy of a few engineers in the latter colony who are fighting a bad cause to the last. And the time cannot be long distant before in this country, also, he must receive a fair acknowledgment of his labor. To depreciate at first, and afterwards to attempt to appropriate, is a human failing, and in the full consciousness of this we have, as we stated at the commencement, written this article. We have not written to aid Mr. Fairlie; there was a time when he needed help, and it was freely rendered by ourselves and by our contemporary, "The Engineer," but that time has passed now; the principles of opposition against him, "conceived in ignorance, maintained in obstinacy," as Mr. Bidder would say, are passing away; and to-day Mr. Fairlie has attained more than a realization of his expectations and his hopes. He has achieved popularity and success to an exceptional degree, and can well afford now to wait till opposition shall be converted into applause and—imitation.

But despite the clearest and most incontrovertible facts, there will not be wanting those who, in the course of a short time, will urge their right to be considered as the authors of the railway reform we have been considering. But

these will walk in a false light, and talk under false pretences; and it is certain that so long as this article shall be read, so long as it shall continue in existence, it will remain an unimpeachable testimony in favor of the man who has devoted the best years of his life to the establishment of narrow-gauge railways, and has won success.

SUBMARINE ROCK SURVEYING.

By G. H. MANN, C. E.

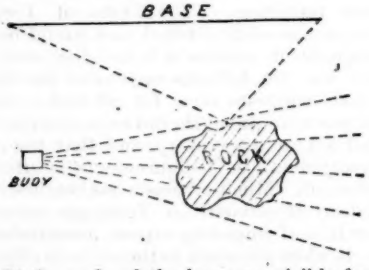
Submarine rocks may be of either of two general classes:—

1*st*. *Inshore Rocks.*

2*d*. *Isolated Rocks.*

Points on the first class can be accurately determined by instrument intersections, but on the second can not, on account of the distance from the shore. It is an important condition in rock surveying that the method employed should not only give the soundings in their proper relation to each other, but also so arranged as to render easy the passing of contour lines upon the map. In waters without currents, straight lines of soundings can be readily run, without anything besides the oars to hold the boat in position. For inshore rocks, lines of soundings can be run from ranges, and the soundings located by 2 instruments on shore. For isolated rocks, 2 boats may be moored, so as to allow but little motion, and used for the extremities of a base, whose length and bearing may be determined. The lines of soundings being run from a barrel buoy, or 2 of them, anchored outside of the rock, the system of lines in the two cases being shown in the figures.

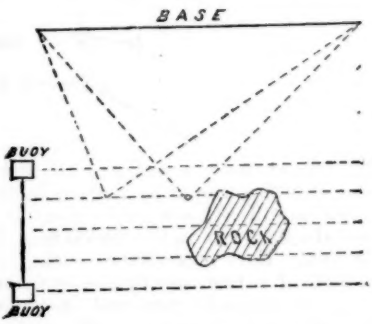
Fig. 1.



If the ends of the base are visible from the shore, they may be located, and the position of the rock thus determined.

In currents, some other means of surveying must be employed, as it is impossible to hold a boat in position by oars alone under such circumstances. As an initial condition, it should be stated that the lines of soundings should always run with the current. The system to be employed for both classes of rocks in such cases is known as the "checker-board" method. In rock surveying, soundings should be taken at not more than 5 ft. apart for small rocks, 10 ft. for large ones, and in case of very limited areas of rock, at every foot. The case of isolated rocks will be considered first, and then the modifications desirable for inshore rocks. Having first made careful soundings around the rock, set small barrel buoys so as to show the extent of the rock. Kerosene oil barrels are then strapped, with eyes opposite each other, on the upper and lower side; 4 of them are then anchored so as to include the whole of the rock, the warps being long enough to prevent dragging the anchors. (See Fig. 3.)

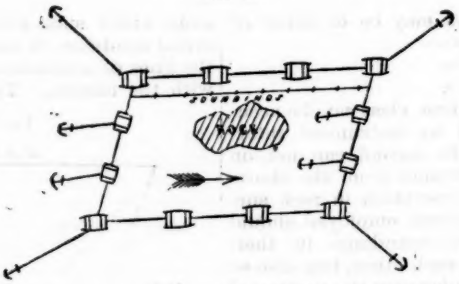
Fig. 2.



These rocks are then strung up in the form of a parallelogram by ropes passing through the upper eyes, and having pieces of red bunting inserted into them at the intervals at which soundings are to be made. For long lines, other barrels must be anchored, as shown, to prevent sagging. A line (l), marked as above, is

then stretched from one parallel side to another, and fastened, the soundings being taken by moving the boat along it, and sounding at every tag. It is then moved along the parallel lines to the next tag, and soundings are thus taken until the whole rock is included. The angle between the base and the sounding line is then taken with a sextant, and the bearing of the base determined. The line of soundings should always start from the side *from* which the current runs. If the current (as in some harbors) changes its direction so as to run across the line of soundings, it is then best to locate them by taking the angle between the line and

FIG. 3.



the base at every sounding. In case of long reefs this should be done, as in such places it will not always be possible to have the lines run in the direction of the current. For very large rocks, the method of a base and two sextants may be advantageously employed in connection with the "checker-board" method. For inshore rocks, the lines need not be marked, but are used simply for the purpose of holding the boat while angles are being taken with the instruments on shore. If thought desirable, the "checker-board" method may be employed, and the buoys located from on shore; for one instrument this is very convenient.

PUBLIC MONUMENTS.

From "The Building News."

The subject of public monuments, and especially effigies of great men, is now under constant discussion, owing to the proposals to adorn the ornamental spaces contiguous to the Houses of Parliament with statues of British statesmen. Few questions of the kind are more difficult, and few are more interesting. We have never in these matters been celebrated. The interiors of St. Paul's and Westminster exhibit a lamentable confusion of mortuary trophies, with which art has had nothing whatever to do—masses of marble, carved enormities and unnatural symbolic groups, in nearly every instance Pagan in design. But, at present, we refer more particularly to open-air statues, though, in passing, it may be noticed that our triumphal columns are generally better placed. That the Doric pillar on Fish-street-hill appears to little advantage is due less to any fault of the architect than to the gradual rising of the earth around its base, and the crowding of the locality with buildings. The Duke of York's Column is nobly pitched, and would be a magnificent ornament to London, were it not for the hideous cage near the top, which suggests once for all that a commemorative pillar should be a monument, and not an observatory, and that the necessity for these disfigurements is utterly artificial. Much criticism has befallen the Nelson Monument in Trafalgar square; but it is of imposing aspect, nevertheless. It is when we come to the *al fresco* effigies of our historical characters that London chiefly fails—not merely in their forms as works of art, but in the situations in which they are erected. Trafalgar square, not long ago, suggested the idea of a lately opened cemetery, with Nelson on a

towering column, Havelock on a pedestal, Jenner in a chair, and the other heroes on horseback. The equestrian effigy of Charles I. is exactly where a statue should be, at a confluence of great thoroughfares and looking down a splendid perspective. Contrast it with the image of Mr. Peabody, disgracefully thrust into a corner at the back of the Royal Exchange. That of James II. at Whitehall is out of sight. As for the others, in the squares they would be decorative if Englishmen understood what a square should be; but they do not. That of Trafalgar is the only one, in the true sense of the term, which our metropolis possesses. The others are mere gardens, railed in and planted. Soho, St. James's, Cavendish—where stands a monument of English shame rather than one of any great man's greatness—Hanover—where a really good figure of Pitt, Chantrey's work, stands in not the worst of positions—Bedford and Russell squares, are all miniature and exclusive parks, each adorned with a statue; but these memorials are not, within the strict meaning of the word, public. Well, to sum up, we have in London 13 images of kings and queens, if it be possible to include the ghastly skeleton in Leicester-square, 3 Wellingtons and 1 Nelson, 3 statesmen, 1 Radical Reformer of the olden type, and 1 popular benefactor of the same class. These are of a far higher order than the absolutely modern works, and not one of them, however secluded, but puts to shame the gross caricature of Richard Cobden's noble figure and features which disfigures the chief thoroughfare of Camden Town. We say nothing of the images erected on the Holborn Viaduct, because they are merely typical, and really adorn the structure, or of the effigies proposed to be niched in Westminster Hall, since that it is not "open-air;" but we would refer to the preposterous Guards' Memorial in Waterloo Place as an example of vulgar clumsiness. Who that has seen the monuments of Goethe and the Three Printers at Frankfort, and that of Rembrandt, at Amsterdam, can fail to take in our meaning? Nor have the French less capacity for erecting stately memorials (albeit for pulling them down also) and fixing upon appropriate sites for their disposition. Never in Paris would have been seen such a grotesque as the Trojan Horse on the top of the arch at Hyde Park Corner, or the Achilles in the corner of Hyde Park. This question is becoming all the more important, not merely on account of the sculpture about to be distributed in the neighborhood of the new Palace of Westminster, but also in anticipation of the statuary which it is proposed to range along the line of the Thames Embankment. The public must be anxious to save this noble thoroughfare from disfigurement and disgrace. But the curious point is, what is the public sense, what is the general expectation upon this subject? Both, undoubtedly, have made great advances. We cannot conceive, in our days, a naked General Wolfe, crowned by a glory, and upheld by a Grenadier; Admiral Holmes as a Roman; Captain Blair riding a sea-horse; Pitt sitting to History, which paints his portrait; Percival lying on a mattress; Sir John Moore receiving a laurel wreath from the Spaniards—of all nations!—or those other allegorical absurdities which were the delight of two or three generations ago, and, indeed, until a later time. Meanwhile, a proposal has been made to classify our public memorials, to reserve cathedrals and abbeys for divines, with, it is presumed, poets, writers, and statesmen, though the rule, strictly applied, would relegate these last to the Houses of Parliament; the inns of court and the courts of justice for jurists; the Halls of medical colleges or of hospitals for eminent medical men; the university halls for men of learning; and the halls of our scientific institutions for men of science. We very much doubt whether any such arrangement would ever satisfy the sentiment which proposes to erect the memorial of a great man. Not that sculpture creates fame, except for the sculptor; but that it is an outward and visible manifestation and proof of it in the eyes of posterity. It would be a mistake to shut up the image of an antiquary among antiquities, or that of a great anatomist among the specimens in the Royal College of Surgeons. But, we repeat, the grand essential is to study what we have, and the possibility of rising to a higher style as to the conception, execution, and settlement in permanent places of our public materials. There does not exist in London a solitary example worthy of being taken as a model; not even "the masterpiece of Grinling Gibbons," as guide-book makers, following one another

with slavish monotony, pronounce it, which we heartily wish had been melted down long ago into knife and fork handles; or that respectable imitation of a Corinthian column, the Nelson Monument, crowned by the somewhat anomalous cocked hat of our naval hero; or Chantrey's George IV. in the attitude of a Brighton riding-master; or the idiotic majesty, though well pitched, of George III., in Cockspur street; or Sir Henry Havelock, in the attitude of a soldier at ease, but with the expression of a Methodist preacher; his companion, Sir Charles Napier, looks like a conceited corporal who has just been complimented by his adjutant. We have noticed the Guards' Memorial, which resembles nothing more than a pastry-cook's trophy; but not the Westminster Boy Memorial, which hath the likeness of a dry drinking-fountain. Oddly enough, one of our best specimens —that of James II.—stands purgatorily in a dirty yard off Whitehall, instead of being placed, for instance, at the intersection of two such streets as Oxford street and Regent street—spots which would not be required exclusively for lamps if our thoroughfare lighting were at all decent. There is Lord George Bentinck, shrouded in the obscurity of Cavendish square; Queen Elizabeth outside, in a disused church-yard; and Queen Victoria inside the Royal Exchange; and George Stephenson consigned to a railway station. Not any of these can very rapturously be recommended. Sir Robert Peel, at the top of Cheapside, occupies an excellent position, as does William IV. in view of London Bridge; but where is Cœur de Lion, after his many mutations? —this statue has always been a sort of nightmare in the sculpture world of England—and where is George Canning, who was so long his maltreated colleague? Let us note a few incidents connected with some of these. That of Pitt, in Hanover square, is without outline—the great fault of our public statues—being muffled up, obediently to a ridiculous tradition, in a semi-Classic, semi-Red Indian, or blanket, toga; that of the Duke of Kent, at the upper end of Portland Place, is nearly smothered among architectural accessories; Chantrey's George IV., in Trafalgar square, though equestrian, is also togaed; that of Jenner, though Trafalgar square has been relieved of it, has been doomed to sit among the verdure and water of the Old Court suburb, where it some day may be mistaken for a river god; indeed, the catalogue, and the criticisms upon it, might be almost indefinitely extended. But a final word of advice to young sculptors who have opportunities of travel. If their school be heroic, let them mark the genius which created Peter the Great at Moscow, and Frederick the Great at Berlin; or, if otherwise, a single monument in Paris may change many of their preconceived ideas—the statue of Moliere, in the Rue de Richelieu, which is perfect. It will be perceived that we have omitted all mention of the Albert Memorial; but this has been purposely.

A strange phenomenon was observed at Delft last year during the operation of boring for water. H. Vogelsang has described that on Aug. 3d, the iron tube had been driven to a depth of 17.5 metres through a bed of alluvium, when gas began to rush up the tube with great violence, followed by a stream of water. The foaming column rose 14 metres into the air, and played for 14 hours without intermission; it then appeared after intervals of 9 min. The intermittent activity lasted till the 21st, and terminated with an evolution of gas alone. The water, when the irruption commenced, contained much iron in the form of carbonate, and had a temperature of 13 deg. Cent. The gas burnt with a large but feebly luminous flame, and was composed, on the 6th of August, of 16.4 volumes of carbonic acid to 83.6 volumes of marsh gas; and on the 16th of the same month, of 11.6 volumes of carbonic to 88.4 volumes of marsh gas. On the 21st the tube was driven further, and at a depth of 30 metres a supply of water reached.

The Joint Committee of the Great Western and Midland Railway Companies' Clifton Extension have resolved to proceed without further delay with the construction of this branch railway. The line is about 3¼ miles in length, and will bring this fashionable suburb of Bristol into direct communication with those railways, and with the Channel docks now in course of construction at Avonmouth.

THROUGH THE EUPHRATES VALLEY.

From "Engineering."

The question of the construction of a line of railway connecting the Mediterranean Sea with the Persian Gulf, as an improved means of communication with India, is one that has practically been before the country for upwards of 40 years; it has already on a former occasion received encouragement from the English Government, and it is with no small degree of satisfaction that we find that it is again to be considered in Parliament, in all its details, by a Select Committee. The early history of this route as a passage between Europe and India has so recently been reviewed in these pages that it is not necessary to go over that ground again. In the discussion on the subject which took place in the House of Commons, some of the leading characteristics of such an alternative route to India as the one proposed were dwelt upon, but owing to the readiness with which Government consented to the appointment of a Select Committee, doubtless many valuable opinions on the subject remain unrecorded which would otherwise have been then advanced in favor of Sir J. Jenkinson's proposition. Whether that motion had its origin in a desire to support any particular project, we are unable to say. In our minds the subject is one of imperial importance to this country both in a political and military sense; it was also shown in the discussion that England had a large interest commercially, first, in its construction, and subsequently in its use, and that to such an extent that some pecuniary assistance towards its establishment seemed to be justifiable, although most of the speakers on the subject appear to have been adverse to the giving of a guarantee for the cost of its construction.

Although certain Members of Parliament appear to have been in favor of limiting the scope of the investigations to be entered into by the Select Committee, it is to be hoped that no such restriction will be placed upon them, for the necessity or advisability of constructing a new highway to India depends, not upon one or two considerations, but upon all the points that may be advanced for or against it. India is now, perhaps, of as much importance to England as England is to India, and any means that can be devised for bringing these two mutual dependencies nearer together, must be of considerable advantage to both of them. Now it has been shown that a railway connecting the Mediterranean Sea with the Persian Gulf, would shorten the actual travelling distance by 1,000 miles, and the time of transit by one week. So direct, too, is the route, that a straight line drawn from London to Bussorah, passes through the very country that would be traversed by the proposed railway. As regards the actual route to be taken, much must, of course, depend upon the results of the actual surveys of the alternative lines that have been proposed. Mr. W. P. Andrew has long been a strong and consistent advocate for the Euphrates Valley line, and, it must be admitted, that it is in a great measure due to his energetic perseverance in advocating his pet scheme that the subject is now likely to enter upon another phase. Amongst the many disadvantages of the Euphrates Valley route, it possesses this one special advantage, namely, that it has been surveyed throughout its entire length, which is more than can be said of any other line. As a through route only, it might perhaps be as good as any other, but through traffic alone is not likely to prove remunerative for a line of railway 850 miles in length, which should, therefore, be carried as much as possible along, or near to, the natural course of the traffic of the country through which it is to pass. Taking for granted that it will be considered preferable to have the western terminus of the railway on the Mediterranean rather than on the Black Sea, the valley of the Tigris presents many advantages over its sister valley for a railway route, possessing, as it does, many important towns between which there exists a considerable amount of traffic already in existence, and it now forms the commercial highway across that part of the country. That the Tigris route is of more importance commercially than the line of the Euphrates has already been sufficiently acknowledged by the construction of the telegraph line in that direction, and

it would be but a rational conclusion that, from a commercial point of view, the telegraph and railway should follow the same route. From political or military considerations it would also probably be found desirable to follow the most populous and frequented route; but the questions as to practicability and cost can be substantially determined only upon actual surveys, although the probability is that the existing trade route has been formed, to some degree, from the natural advantages for traffic presented by the line of country which has now for many centuries maintained its existence. The physical difficulties of the proposed railway must form a not unimportant point for consideration, as upon it so many other questions depend, and no investigation can be complete that is not based upon this as one of primary importance.

It would hardly be wise to leave out of consideration the question of cost, and probable remuneration of any proposed line that may commend itself to the Select Committee upon other grounds. Whatever be the character of the railway to be constructed—whether of broad or narrow gauge, of single or double line of way—these questions will be unaffected in principle, for the line that is best for one class of railway will most likely be found—with very trifling variations—to be best for the other. Advocates for both broad and narrow gauges will doubtless put in an appearance before the Select Committee; their differences of opinion will, however, only have a relative effect as regards the relation of probable returns to capital outlay, which must, under any circumstances, be more favorable to the narrow-gauge advocates. This, however, is a detail, which, though it cannot be entirely overlooked by the Committee as affecting the probability of the line being taken up by capitalists, may in a great measure be left for ultimate determination. With regard to cost, and the means of constructing any line that may be recommended for adoption, it was originally estimated that the Euphrates Valley line would cost about £8,000,000. That was before the days of narrow-gauge lines. Mr. Fairlie has, in a recent letter to the "Times," set down the probable cost of a 3 ft. line at £4,000,000, or an average of about £4,500 a mile. On the 27th of September, 1856, the Earl of Clarendon forwarded a telegram to the Chairman of the Euphrates Valley Railway to the effect that it was expected that the Sublime Porte would guarantee 6 per cent. on a capital of £8,000,000 for a railway from the Mediterranean Sea to the Persian Gulf (see the "Times" newspaper for the 21st of November, 1856), and the Turkish Government appears to be still favorable to such a project, which could not but greatly affect the prosperity of the country. Without the aid of some Government assistance—whether in the shape of a subsidy, or guarantee either of cash, or, what would be an equal equivalent, of a certain amount of traffic—it is not likely that funds will be easily obtained for such a large undertaking. If, however, the Sublime Porte could be induced to offer a small guarantee, and our Government to promise the Indian mails and a certain amount of traffic annually, there ought to be no difficulty in carrying out any project that the Select Committee may ultimately recommend. If any railway to connect the Mediterranean with the Persian Gulf can be constructed for, say, £5,000,000, and be maintained only by its own traffic, without giving any return for capital, it would surely prove a more remunerative scheme for this country than doing away with purchase in the army, and as such we recommend it to Mr. Lowe as an item for his next budget.

The whole question of course turns upon the importance of improving our means of communication with India. It has been shown that a railway connecting the Mediterranean with the Persian Gulf would lie in the most direct line between this country and India. Having its termini on two seas, it could easily be held and defended by our navy, which would be very important in the event of any disturbance on the part of Russia on our Eastern frontier, or in the event of our being suddenly and unexpectedly called upon to carry out our treaty obligations with respect to Turkey.

Road Steamers in Brazil.—Privileges have been granted in the Brazilian province of Rio Grande do Sul for two roads intended for Thomson's road steamers.

THE MANUFACTURE OF RUSSIAN SHEET-IRON.*

From "The Builder."

A particular kind of sheet-iron is manufactured in Russia, which seeems not to have been produced elsewhere. It is remarkable for its smooth, glossy surface, which is dark metallic gray, and not bluish gray, like that of common sheet-iron. On bending it backwards and forwards with the fingers, no scale is separated, as is the case with sheet-iron manufactured in the ordinary way by rolling; but on folding it closely, as though it were paper, and unfolding it, small scales are detached along the line of the fold.

This sheet-iron is in considerable demand in Russia for roofing, and in the United States, where it is largely used in the construction of stoves and for incasing locomotive engines. It is there named stove-pipe iron.

Russian sheet-iron has been recently subjected to chemical examination in the Metallurgical Laboratory of the Royal School of Mines, and the analytical work has been executed by Dr. Percy's assistant, Mr. W. J. Ward.

The occurrence of a peculiar carbonaceous mass, left after the solvent action of dilute hydrochloric or sulphuric acid, may reasonably be accounted for, Dr. Percy says, by the method of manufacturing Russian sheet-iron, which he describes. The sheets are interstratified with charcoal-powder, and bound up in packets, each of which is subjected to repeated hammering. Hence, it is easy to conceive how fine particles of charcoal should be beaten in over both surfaces of each sheet; and, if this be so, a relatively larger proportion of carbon should exist in the thin sheet, as is the case. Yet that some of the carbon is combined, may be inferred from the fact that distinct hardening occurs after heating the metal to redness, and immersing it while hot in water, and especially in mercury.

In the volume on iron and steel, which Dr. Percy published in 1864, he stated that the mode of manufacturing the Russian sheet-iron in question was kept rigidly secret; that it was made from iron smelted and worked throughout with charcoal as the fuel; that according to information which he had received from three independent sources, the sheets, after the completion of the rolling, were hammered in packets with charcoal-dust interposed between every sheet; and that they were subsequently assorted, and the outer ones, being inferior in quality, were thrown aside as wasters.

Our author has since found that the secrecy was more dependent on ignorance of the Russian languange than on anything intentional; and he now gives various particulars of the process.

The manufacture of sheet-iron in Russia, he says, is chiefly confined to the iron works on the eastern side of the Oural Mountains. The malleable iron, which is the subject of this manufacture, is derived from pig-iron, obtained by smelting the following ores with charcoal in cold-blast furnaces,—namely, magnetine, carbonate of iron (*sphæro siderite*), and red and brown hematite. The converson of the pig-iron into malleable iron is effected either in the charcoal-finery or in the puddling furnace.

The puddle-balls intended for the manufacture of sheet-iron, are rolled into bars 5 in. wide and ¼ in. thick. The iron should be more crystalline than fibrous, and should contain sufficient carbon to render it more like steel than iron. The machinery required consists of one or two pairs of rolls and two kinds of hammers. Reheating is conducted in furnaces of particular construction. The rolls are driven by water-wheels, and should make not fewer than 50 revolutions a minute. The hammers are also put in motion by cams on the axles of water-wheels. The hammer-heads are of wrought iron, with striking faces of steel. Each anvil consists of a solid block of white cast iron. It is necessary that the hammers and anvils should be so made, in order that they may have the requisite hardness, in default of which the surfaces of the sheets would not acquire sufficient brightness or polish.

The puddle-bars, 5 in. wide and ¼ in. thick, are cut into pieces 29 in. long, which weigh about 15.35 lbs. avoird. (10 lbs. ?—J. P.) These pieces are heated to redness, and cross-rolled into sheets about

* The Manufacture of Russian Sheet-Iron. By John Percy M. D., F. R. S., Lecturer on Metallurgy at the Royal School of Mines, etc. With illustrations. London: John Murray, Albemarle street. 1871.

29 in. square; and in order to become thus extended, they require to be passed through the rolls about 12 or 14 times. The sheets thus produced are arranged in packets of 3 in each, heated to redness, and rolled, each packet passing through the rolls about 10 times. But just before rolling, the surface of each packet is cleaned with a wet broom, usually made of the green leaves of the silver fir, and powdered charcoal is strewn between the sheets.

The sheets obtained from this rolling are sheared in the dimensions of 28 in. by 56 in. Each sheared sheet is brushed all over with a mixture of birch charcoal powder and water and then dried. The sheets, so coated with a thin layer of charcoal powder, are arranged in packets containing from 70 to 100 sheets each; and each packet is bound up in waste sheets, of which 2 are placed at the top and 2 at the bottom. A single packet at a time is reheated, with logs of wood about 7 ft. long placed round it, the object of which is to avoid, as far as possible, the presence of free oxygen in the reheating chamber. The gases and vapors evolved from heated wood contain combustible matter, which would tend to protect the sheets from oxidation in the event of free oxygen finding its way into the reheating chamber.

The packet is heated slowly during 5 or 6 hours, after which it is taken out by means of large tongs and hammered. The packet is moved so that the blows fall in an order indicated by diagram. After this treatment the surface of the packet presents a wavy appearance, as the striking face of the hammer and the face of the anvil are both very narrow. When the packet has travelled about 6 times under the hammer, in the manner specified, it is removed; and immediately afterwards completely finished sheets are arranged alternately between those of the packet.

The actual cost of manufacturing these Russian sheets is about £12 15s. per ton, to which must be added general charges, which raise the amount to £16 or £17 per ton, exclusive of profit. The average price of sheet-iron at the fair of Nijni-Novgorod is about £22 or £25 per ton.

THE DISTRIBUTION OF TEMPERATURE IN THE NORTH ATLANTIC.*

By WYVILLE THOMSON.

From "Nature."

At the request of the Council of the Scottish Meteorological Society, I beg to bring before you a sketch of the more recent results of investigations into the causes of the abnormal climate of the surface of a great portion of the North Atlantic Ocean, and of the lands which form its north-eastern borders; and especially the results of the deep-sea exploring expeditions of the last 3 years, in which I have taken a part, so far as they bear upon this point.

In a recent valuable report on the Gulf Stream in the "Geographische Mittheilunger," of last year, Dr. Petermann severely, and, I think too, justly reflected upon us students of ocean temperatures for giving ourselves up to wild and gratuitous speculation. I wish, if possible, on the present occasion, to avoid all risk of such impeachment, by limiting our inquiry rigidly for the few minutes I have at my disposal, to the present condition of our knowledge of facts, and to such deductions from these as may be fairly considered proved.

Let us then first inquire for a moment what the phenomena are which we are called upon to correlate and to explain. There is no dispute about these facts, and a glance at the chart will at once recall them to your recollection. In the first place, the lines of equal mean annual temperature, instead of showing any tendency to coincide with the parallels of latitude, run up into the North Atlantic and into the North Sea, in the form of a series of long loops. This diversion of the isothermal lines from their normal direction is admittedly caused by surface ocean currents conveying the warm tropical water towards the polar regions, whence there is a constant counter-flow of cold water beneath to supply its place. This

* Address delivered to the Meteorological Society of Scotland at the General Meeting of the Society, July 5th.

phenomenon is not confined to the North Atlantic. A corresponding series of loops, though not so well defined, passes southwards, along the east coast of South America, and a very marked series occupies the north-eastern angle of the Pacific, off the Aleutian Islands and the coast of California. The temperature of the land is not affected directly by the temperature of the sea in its immediate neighborhood, but by the temperature of the prevailing wind, which is determined by that of the sea. Setting aside the still more important point of the equalization of summer and winter temperature, the mean annual temperature of Bergen, lat. 60 deg. 24 min. N., subject to the ameliorating influence of the south-west wind blowing over the temperate water of the North Atlantic, is 6.7 C., while that of Tobclsk, lat. 58 deg. 13 min., is 2.4 deg. C.

But the temperature of the North Atlantic is not only raised greatly above that of places on the same parallel of latitude having a continental climate, by this interchange of tropical and polar water, but it is greatly higher than that of places apparently similarly circumstanced as to a general interchange of water in the Southern Hemisphere. Thus, the mean annual temperature of the Faroe Islands, lat. 62 deg. 2 min. N., is 71 deg. C., nearly equal to that of the Falkland Islands, lat. 52 deg. S., which is 82 deg. C., and the temperature of Dublin, lat 53 deg. 21 min. N., is 9.6 deg. C., while that of Port Famine, lat. 53 deg. 8 min. S., is 5.3 deg. C. Again the high temperature of the North Atlantic is not equally distributed, but is very marked in its special determination to the north-east coasts. Thus, the mean annual temperature of Halifax, lat. 44 deg. 39 min., is 6.2 deg. C., while that of Dublin, lat. 53 deg. 21 min. is 9.6 C., and the temperature of Boston (Mass.), lat. 42 deg. 21 min., is exactly the same as that of Dublin.

We thus arrive at the well-known general result, that the temperature of the sea bathing the north-east shores of the North Atlantic is greatly raised above its normal point by currents involving an interchange of tropical and polar water; and that the lands bordering on the North Atlantic participate in this amelioration of climate by the heat imparted by the water to their prevailing winds.

We shall now examine this distribution of ocean temperature a little more minutely. During the last many years, a prodigious amount of data have been accumulating with reference to the detailed distribution of heat on the surface of the North Atlantic basin, and last year M. Petermann, of Gotha, published in his "Geographische Mittheilungen" a series of invaluable temperature charts embodying the results of the reduction of upwards of 100,000 observations derived mainly from the following sources:—

1*st*. From the wind and current charts of Lieut. Maury, embodying about 30,000 distinct temperature observations.

2*d*. From 50,000 observations made by Dutch sea-captains and published by the Government of the Netherlands.

3*d*. From the journal of the Cunard steamers between Liverpool and New York, and of the steamers of the Montreal Company between Glasgow and Belleisle.

4*th*. From the data collected by our excellent secretary, Mr. Buchan, with regard to the temperature of the coast of Scotland.

5*th*. From the publications of the Norwegian Institute on sea temperatures between Norway, Scotland, and Iceland.

6*th*. From the data furnished by the Danish Rear-admiral Irminger on sea temperatures between Denmark and the Danish settlements in Greenland.

7*th*. From the observations made by Lord Dufferin on board his yacht Foam between Scotland, Iceland, Spitzbergen, and Norway.

And finally from the recent observations collected by the English, German, Swedish, and Russian expeditions to the Arctic regions and towards the North Pole.

Dr. Petermann has devoted the special attention of a great part of his life to this question, and the accuracy of his results in every detail is beyond the shadow of a doubt. Every curve of equal temperature, whether for the summer, for the winter, or for the whole year, instantly declares itself as one of a system of curves which are referred to the Strait of Florida as the source of heat, and the warm water may be traced (and this is not begging the question, for the temperature is got by dipping the thermometer in the water), in a continuous stream, indicated where its movement can no longer be observed by its form, fanning out from the neighborhood of the Strait across the Atlantic,

skirting the coasts of France, Britain, and Scandinavia, rounding the North Cape, and passing the White sea and the Sea of Kari, bathing the western shores of Novaja Semla and Spitzbergen, and finally coursing round the coast of Siberia, a trace of it still remaining to try to find its way through the narrow and shallow Behring Strait into the North Pacific. Now it seems to me that if we had these observations alone, which are merely detailed and careful corroborations of many previous ones, and could depend upon them, without even having any clue to their *rationale*, we should be forced to admit that whatever might be the amount and distribution of heat derived from a general oceanic circulation, whether produced by the prevailing winds of the region, by convection, by unequal barometric pressure, by tropical heat, or by arctic cold, there is besides this some other source of heat at the point referred to by these curves sufficiently powerful to mask all the rest, and, broadly speaking, to produce of itself all the perceptible deviations of the isotherms from their normal course.

But we have no difficulty in accounting for this source of heat. As is well-known, about the equator, the north-east and south-east trade winds reduced to meridional directions by the eastward frictional impulse of the earth's rotation, drive before them a magnificent surface current of hot water, the equatorial current 4,000 miles long and 450 miles broad, at an average rate of 30 miles a day. This current splits upon Cape St. Roque, and one portion trends southwards to deflect the isotherms of 21 deg. 15.5 deg., 10 deg., and 4.5 deg. C. into loops, thus carrying a scrap of comfort towards the Falklands and Cape Horn. While the remainder, "having made the circuit of the Gulf of Mexico, issues through the Straits of Florida, clinging in shore round Cape Florida, whence it issues as the Gulf Stream, in a majestic current upwards of 30 miles broad, 2,200 ft. deep, with an average velocity of 4 miles an hour, and a temperature of 86 deg. Fahr." (Herschel.)

I need scarcely follow the course of the Gulf Stream in detail, it is generally so well known. After leaving the Strait of Florida, it strikes in a north-easterly direction, comformable generally to the easterly impulse given by its excess of diurnal rotation, towards the coast of Northern Europe. About 42 deg. N. a large portion of it, still maintaining the high surface temperature of 24 deg. C., turns eastward and southward, and, eddying round the Sargasso Sea, fuses with the northern edge of the equatorial current, and rejoins the main circulation. The main body, however, moves northwards. Mr. Croll, in a very suggestive paper in the "Philosophical Magazine" on Ocean Currents, estimates the Gulf Stream as equal to a stream of water 50 miles broad and 1,000 ft. deep, flowing at a rate of 4 miles an hour, with a mean temperature of 18 deg. C. I see no reason whatever to believe this calculation to be excessive, and it gives a graphic idea of the forces at work.

The North Atlantic and the Arctic seas form together a basin closed to the northward, for there is practically no passage for a body of water through Behring's Strait. Into the corner of this basin, as if it were a bath, with a north-easterly direction given to it, as if the supply pipe of the bath were turned so as to give the hot water a definite impulse, this enormous flood is poured day and night, winter and summer; almost appalling in its volume and the continuity of its warmth, and its blueness, and brilliant transparency, *in sæcula sæculorum!*

The hot water pours, not entirely from the Strait of Florida, but partly from the Strait and partly in a more diffused current outside the islands, with a decided, though slight north-easterly impulse on account of its great initial velocity. The North Atlantic is with the Arctic Sea a *cul-de-sac*. When this basin is full—and not till then—overcoming its northern impulse, the water tends southwards in the southern eddy, so that there is a certain tendency for the hot water to accumulate in the northern basin. It is to this tendency, produced by the absence of a free outlet to the Arctic Sea, that I would be inclined to attribute the special excess of the warmth of the north-eastern shores of the North Atlantic.

When ascertaining with the utmost care and with the most trustworthy instruments, by serial soundings, the temperature of the area surveyed by the Porcupine in 1869, we found at a depth of 2,435 fathoms in the Bay of Biscay, that down to 50 fathoms the temperature of the sea was greatly affected by direct solar radia-

tion; from 100 to 900 fathoms the temperature gradually fell from 10 deg. C. to 4 deg. C., and from 900 fathoms to 2,435, the fall of temperature was almost imperceptibly gradual from 4 deg. to 2.5 deg. C.

The comparatively high temperature from 100 fathoms to 900 fathoms I am certainly inclined to attribute to the northern accumulation of the water of the Gulf Stream. The radiant heat derived directly from the sun must, of course, be regarded as a constant quantity superadded to the original temperature of the water derived from other sources. Taking this into account, the surface temperatures in what we were in the habit of calling the "warm area" coincided precisely with Petermann's curves indicating the northward path of the Gulf Stream.

It is scarcely necessary to say, that for every unit of water which enters the basin of the North Atlantic, an equivalent must return. From its low velocity, the Arctic return current or indraught will doubtless tend slightly to a westerly direction, and the higher specific gravity of the cold water may probably even more powerfully lead it into the deepest channels; or, possibly, the two causes may combine, and in the course of ages may tend to hollow out deep south-westerly grooves. At all events, the main Arctic return currents are very visible on the chart taking that direction, indicated by marked deflections of the isothermal lines. The most marked is the Labrador current, which passes down inside the Gulf Stream along the coast of Carolina and New Jersey, meeting it in the strange, abrupt "cold wall," dipping under it as it issues from the Gulf, coming to the surface again on the other side, and a portion of it actually passing under the Gulf Stream as a cold counter-current into the deeper part of the Gulf of Mexico.

50 or 60 miles from the west coast of Scotland, I believe the Gulf Stream forms another though a very mitigated "cold wall." In 1868, Dr. Carpenter and I investigated a very remarkable cold indraught into the channel between Shetland and Faroe. In a lecture on deep-sea climates, which was published in "Nature," in July last, I stated my belief that the current was entirely banked up in the Faroe channel by the Gulf Stream passing its gorge.

Since that time I have been led to suspect that a part of the Arctic water oozes down the Scottish coast much mixed, and sufficiently shallow to be affected throughout by solar radiation. About 60 or 70 miles from shore the isothermal lines have a slight but uniform deflection. Within that line types characteristic of the Scandinavian fauna are numerous, and in the course of many years' use of the towing net, I have never met with any of the Gulf Stream pteropods, or of the lovely Polycystinæ and Acanthometrinæ, which absolutely swarm beyond that limit. The differences in mean temperature between the east and west coasts of Scotland, amounting to between 1 deg. and 2 deg. Fahr., is also somewhat less than might have been expected.

There is another point which is worthy of consideration. It is often said that about the latitude 45 deg. N., the Gulf Stream thins out and disappears. The course of a warm current is traced farther on the maps, even to the coast of Norway and the North Cape, but this north-easterly extension is called the Gulf Stream drift, and is supposed to be a surface flow caused by the prevailing S. W. anti-trades. There seem to me to be several arguments against this view. The surface of the sea, at all events between 40 deg. and 55 deg. N., has a mean temperature higher than that of the air, and that could scarcely be the case unless there were a constant supply, independent of the wind, of water from a warmer source; and any question is, to my mind, entirely set at rest by our establishment of the mass of warm water moving to the north-eastward, whose curves of excess of temperature, so far as they have as yet been ascertained, correspond entirely with those of the Gulf Stream.

I cannot at present enter at any length into the very fundamental question which has lately given rise to so much discussion, whether the Gulf Stream is actually the agent in conveying heat to the North Atlantic and ameliorating the climate of its north-eastern shores, or whether these results are not rather produced by a "general oceanic circulation."

As, however, I am frequently quoted by my friend and colleague in much scientific work, Dr. Carpenter, as holding an opinion different from his, and as my present remarks place my views beyond doubt, it may be well to give a reason for my want

of faith. Dr. Carpenter's view, if I understand him rightly, is that there is a great general convective circulation in the ocean, on the principle of a hot-water heating apparatus, and that the Gulf Stream is only a modified and partial cause of this general circulation. Now, in the first place, as I have already said, it seems to me that the distribution of warm water in the North Atlantic has been traced to its source, and all the general phenomena of the Gulf Stream, its origin, its course, its extension, and its depth at certain points, have been *proved* by the careful observations of many years, which I see no reason whatever to doubt. The constant impulse of the trade wind drives a broad current of equatorial water against the American coast. A great part of this current is observed to turn northwards through the Strait and round the islands, and to pour an eternal flood of hot water in a certain direction, under known laws, into the closed basin of the North Atlantic, and as a natural consequence the temperature is very considerably raised.

We are undoubtedly most deeply indebted to Dr. Carpenter for the forcible way in which he has brought forward the arguments on the other side; and, after carefully considering everything, I am thoroughly willing, with Sir John Herschel, to cede that "there is no refusing to admit that an oceanic circulation of some sort must arise from mere heat, cold, and evaporation as *veræ causæ*;" and that "henceforward the question of ocean currents will have to be studied under a two-fold point of view;" but my strong conviction is that if the sagacious philosopher whose loss we now deplore, had been spared so to study it, he would have only been strengthened in his verdict of 1861 as to the Gulf Stream, that there can be no "possible ground for doubting that it owes its origin entirely to the trade-winds." Dr. Carpenter attributes the general oceanic circulation, of which he regards the Gulf Stream as only a modified case, to tropical heat and evaporation, and arctic cold, possibly aided by differences of barometric pressures; or to convection pure and simple, as illustrated in his experiments before the Royal Institution and the Geographical Society. Now, what we expect of Dr. Carpenter before we are called upon to accept to the full his magnificent generalization, is a calculation and demonstration of the amount of the effect of the causes upon which he depends acting under the special circumstances. We must remember that heat is received by the ocean at the surface only, and that owing to cold indraughts all over the globe, so far as we know, the temperature falls the deeper we go; that all our observations tend to show that the temperature of the sea is only influenced by direct solar radiation to any amount to the depth of 50 fathoms, so that all currents depending upon difference between equatorial and polar temperatures, must be produced and propagated in a film of water about the depth of the height of St. Paul's and 6,000 miles long. The black line bounding that chart represents pretty nearly the depth of the ocean, and even were the whole of the water supposed to be involved in the movement, it would be difficult to imagine a perceptible current to be produced in so thin and wide a sheet by such feeble cause. It would be impossible to indicate by the finest hair line the tenuity of the film which is actually affected by the direct rays of the sun. How differences in barometric pressure can produce constant currents I do not see. Rapid fluctuations in pressure in places within a short distance of one another, will doubtless produce readjustment by a wave motion; but constant differences of pressure will simply produce constant differences of level and no currents. Varying pressures at very distant points cannot possibly produce a constant current. I freely admit that I am quite incapable of undertaking the investigations which might lead to the estimation of the relative or actual importance of these causes of currents. I have several times put the question to specialists in such physical inquiries, but they have always said that it was a matter of the greatest difficulty, but that their impression was that the effects would be infinitesimal.

I fear, then, that, in opposition to the views of my distinguished colleague, I must repeat that I have seen as yet, no reason to modify the opinion which I have consistently held, that the remarkable conditions of climate on the coasts of Northern Europe are due in a broad sense solely to the Gulf Stream; that is to say, that while it would be madness to deny that in a great body of water at different temperatures, under varying barometric pressures,

and subject to the surface drifts of variable winds, currents of all kinds, variable and more or less permanent, must be set up; yet the influence of the great current which we call the Gulf Stream, the reflux in fact of the great equatorial current, is so paramount as to reduce all other causes to utter insignificance.

NITRO-GLYCERINE TEST.

From the St. Louis "Journal of Commerce."

A few days ago we announced the presence in the city of Dr. Carl W. Volney, the efficient and accomplished representative of the Lake Shore Nitro-Glycerine Company, of Painesville, Ohio, who had just finished the work of driving a tunnel through the hard lithographic limestone 300 ft., at Hannibal, to secure an approach to the new bridge. The result was that Dr. Volney was at once engaged to make a practical test for the Pilot Knob Company, and orders were given by President McCune that the proper arrangements be made, at either Pilot Knob or Shepherd Mountain, to give a severe test.

Mining being one of the specialties of the "Journal," our mining editor accompanied Dr. Volney to Pilot Knob, to witness the test, and is therefore able, as an eye-witness, to give the result. Two holes that had previously been drilled in solid iron ore for powder, say 2 in. in diameter and from 8 to 9 ft. deep, were used. The burthens of these were from 8 to 9 ft., and the iron ore was cleaned off, probably from 100 to 150 tons in each case, and the ore broken so small that block-holing or further reduction could be dispensed with. All who were present were greatly astonished with the result, and with the power of this great explosive.

But the most astonishing result was attained in blasting in the hard porphyry, where a hole had been drilled only 2 in. in diameter and 7 ft. deep, with a burthen of about 10 ft. The explosion was truly terrific! It not only broke off all the solid rock in front and on either side, but to a depth of 15 ft. below the hole, and shattered and loosened the previously solid rock some 6 or 8 ft. back of the hole, thus really cracking the rock in the rear and on both sides, in an area of probably 30 ft.

Hundreds of tons of rock and ore were thus thrown down by each of these explosions, proving satisfactorily that this is the most effective and powerful explosive agent ever used in this region.

The Arcadia House is fully 2 miles from the location where the test was made; yet Mr. Robinson, of the Arcadia Hotel, and several citizens of Ironton, state that they distinctly felt the shock of the explosion.

The holes used for these tests had been drilled for powder, and were not of proper proportions. Had they been drilled for this purpose, there should have been 12 or 15 ft. greater burthen — the holes should have been 20 to 30 ft. from the edge of the rock or iron.

Several points were satisfactorily decided: 1. That nitro-glycerine is at least 12 times more powerful than powder. 2. That one-half the drilling can be saved by its use. 3. That there is no ore or rock that cannot be moved by it. 4. That it can be handled with safety by those who understand it.

The Lake Shore Nitro-Glycerine Company, of Painesville, Ohio, have already used it successfully in driving the tunnel through at Hannibal, and in mining operations at Lake Superior during the past 2 years.

We have heretofore withheld our endorsement, because it has been considered very dangerous, either in transportation or in handling. But in the occasion before us, we notice that the ingredients of which this explosive is composed are kept entirely separate until they are needed for use, when they are brought together. Until this combination, there is no more danger than from the breaking of a can of nitric or sulphuric acid. Dr. Volney's plan is to erect a shed at the mines, remote from any other buildings, where small quantities can be prepared, and thus the risk and danger are avoided; and as he has used it probably more extensively than any other person in this country, and with greater success, we have confidence in the results as foreshadowed by him.

We anticipate as a result of this practical test, that our miners who have large masses of iron ore to blast, and railroad contractors, will be interested in employing this most powerful agency.

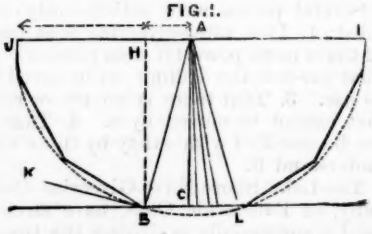
One feature that will be of interest is this: The nitro-glycerine can be graduated, so that a light charge will merely crack or loosen the rock, or break it into small pieces It is hardly necessary to say that the last charge, in the porphyry rock of Pilot Knob, was a large one, and that the result was the most astonishing of any ever made in this State.

TRACTION OF ROAD STEAMERS.

By L. WAGONER, C. E.

Permit me to call the attention of your readers to the August number of the current volume relating to the "bite" of elastic wheels. The position taken by the author of the article is, that the leverage obtained at the point B, Fig. 1, is one of the causes of the increased "bite." That it has nothing at all to do with it will be obvious upon inspection of the figure. The pressure upon each side of the point C is the same while at rest, and the position

FIG. 1.



taken by Mr. Todd, that "a certain amount of power must be applied at I great enough to raise the total weight on the wheel while turning at B," would be correct were it not for back pressure from C L. If the two forces are in equilibrio while at rest, they are the same while in motion; and, therefore, the only changes that take place in an elastic wheel are two, viz.: the wheel is reduced in diameter by the depth of compression, and the weight is removed from the theoretical point of tangency and distributed over the compressed surface. The doctrine, that friction is independent of surface but proportional to pressure, only applies to surfaces of a moderate degree of smoothness, and in the case of the road steamers will not hold good at all. Were the bodies both smooth and elastic as rubber upon ice, the only difference that would ensue would be in the coefficient of friction of the substances in contact. In the case of the so-called smooth bodies in contact, the atoms must be in a plane or curved surface as near as practicable; whereas, in the case of the road steamer, the surface of the track (road) is full of irregularities, and the wheels sinking into them, the tendency to slip must produce a shearing strain upon the wheel and track. And, finally, it will be seen by reference to experiments on the friction of vehicles, that extent of surface in contact does influence and increase the resistance to rolling loads.

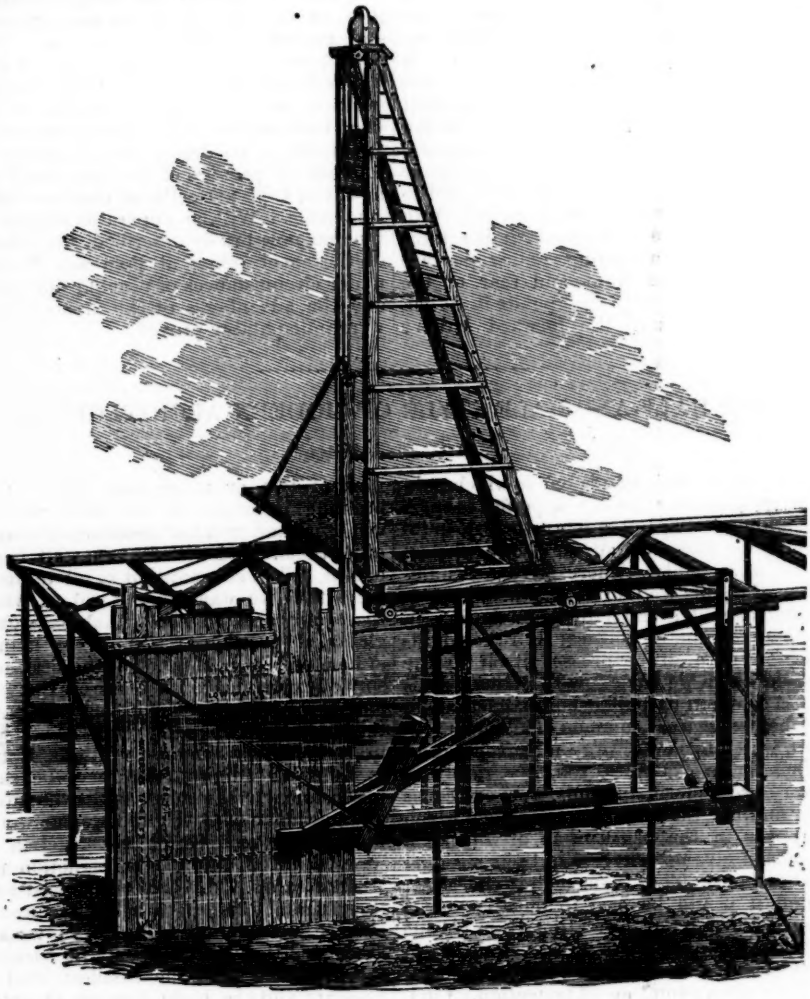
Lawrence, Kansas.

The whole of the ironwork upon the Southern Embankment is now being painted with the patent indestructible paint. If this paint really possesses the advantages claimed by its inventors of resisting the action of acids, and of sea water, as well as that of being nearly indestructible by time, the invention is a matter of almost national importance. One example of the paint has had a 3 years' trial, and has come out up to the present time triumphantly. The ironwork and lamp-posts of the Holborn Viaduct were originally painted with it, and even upon the parapets of the bridge the paint is still as fresh and well preserved as when first put on. When this is compared with the other paint upon iron, put on about the same date, the most striking difference will be at once seen.

The Chancellor of the Exchequer states that the ground plans of the New Courts of Justice have been prepared, and, he might say, completed. The plan of the elevation has been placed in the Library of the House, in order to invite the comments of honorable members upon it.

TOWLE'S "SPIDER" FOR DRIVING PILES IN DEEP WATER.

From "Engineering."



One of the most interesting exhibits of this class was a model of a "spider," designed by Mr. Hamilton E. Towle, and described by him on a recent occasion in the course of a paper upon the construction of the basin of the Pola Docks in the Adriatic. The object of this ingenious contrivance is to facilitate the operations of sinking sheet piles in deep water, and to insure their being fairly driven and kept in a true line. The spider consists of a framing suspended from the staging from which the piles are driven, by 2 vertical timbers, free to swing, and hinged at their lower ends to the horizontal bars that form the most important part of the

spider. These consist of 2 long timbers placed parallel to each other, and at such a distance apart that the piles to be driven may pass freely between them. The rear end is heavily weighted, and the forward end of the timbers, which are somewhat reduced in section, serve as jaws to embrace the sheet piles, a few of which it is necessary should be driven before the spider is put into operation. At a short distance from the end of the jaws a raking strut is secured between the horizontal timbers in such a way as to form a guide in driving the piles. It will be understood that the whole apparatus is free to swing upon the 2 vertical timber links attached to the staging, and ropes are attached to the front and rear of the horizontal timber to manipulate it. When brought into use, the forward hawser hauls upon the open jaws of the spider, until they embrace the sheet piles already driven, and the raking strut before mentioned is hard against the face of the outside pile. On a fresh pile being lowered, the end is engaged by the raking strut and timber forming a guide, until the point is brought up by the throat of the spider, which presses against the piles in position; when the falling weight is applied the spring in the hawser permits the apparatus to be driven back sufficiently to allow the passage of the pile, which is, however, kept perfectly in position until it is home. With an apparatus similar to the one now briefly described, the whole of the sheet piling at Pola was driven, under circumstances of peculiar difficulty, and the advantages of the arrangement were indisputably proved.

THE HALF-AND-HALF STYLE OF MODERN ARCHITECTURE.

From "The Building News."

If the present time is one in which public opinion on a variety of points is thoroughly unsettled, it is one in which public taste seems equally subject to change and uncertainty. There are a vast number of people who do not know their own minds about architecture, any more than about religion or politics; and their hesitation naturally expresses itself in the style which we have now to notice. It is less common in public buildings than in others, and least common of all in churches, which form so large a percentage of them. Its examples, too, are rarely of very great merit, and thus, from one cause or another, the selections from them which appear in the pages of an architectural journal give no criterion of their absolute abundance. They vary much in character, and it would be easy to put together a series in regular gradation, from Gothic designs containing a little Classic, down to Classic ones modified by a little Gothic. They are a symptom of transition, of dissatisfaction with existing types, of readiness to accept new ideas. They may possibly be steps on the road to another permanent system, but they can hardly be permanent themselves. The half-and-half style is too crude and disorganized to endure.

This fashion of mixing up the peculiarities of two or more past manners of building is often, as we have said, a symptom and result of dissatisfaction with all of them. It is felt that they all, more or less, fail to suit us; that in all there is much that we want to get rid of, while there may also be much that we would gladly, if possible, retain. This hybrid system of design, if taken at the best, is a sort of experiment: its followers may be looked on as inquiring whether it is practicable to keep the useful and reject the useless amongst the art-traditions of the past. "We admire," they may be supposed to say, "the massiveness, breadth, and grandeur of Greek and Roman work; but we see that Greek construction is unscientific, and Roman construction untruthful. We admit that both owed half their characteristics to a climate and a civilization different from ours; we are convinced that both can only be successfully imitated with the costliest kind of masonry and the highest finish of detail —that both, in short, are so expensive that we can rarely afford to do more than caricature them. On the other hand, we admire the skill and truthfulness of Gothic construction, the ease with which the pointed style adapts itself to circumstances, the freshness and naturalness of much of its ornament. But it, too, looks

unreal, if literally revived; its spirit is not the spirit of modern times; it tends to be fantastic, romantic, over-picturesque. We do not want to disguise our shops in middle-age costume, nor to put our warehouses into a sort of fancy ball dress; and we mean to try if the Classic simplicity of expression cannot be joined to Gothic honesty and naturalness of design." The aim seems plausible enough, and is, in fact, to a great extent a good one. The mistake lies in uniting the details of two styles, and supposing that this is the way to unit their spirit. What needs doing is something much more subtle and difficult than this, otherwise every pupil and office-boy might invent a new style. Still, these attempts, unsuccessful as most of them are, have something to teach. They often show where a change is wanted, though they seldom show exactly what that change should be. The details which they agree to reject, whether Gothic or Classic ones, are likely, though not certain, to be found in reality objectionable. They may, indeed, be set aside through prejudice, but it is equally probable that good cause exists for their disuse.

Of the Gothic details omitted in these hybrid structures, one of the most constant is the tracery window. Here, at least in civil and domestic work, the omission is a natural one. As long as the public prefer sashes to casements, so long, at least, will slender tracery be out of place. The horizontal lines of the sash are so marked that nothing but a solid pier or column will keep them in due subordination. Joined to the attenuated detail of the later Gothic, they catch the eye and rival the stone mullions in importance. They cut the light of the window most unpleasantly in two, and destroy the vertical tendency of the design. And apart from this, sash-frames make mullions plainly unnecessary. What need is there of stone work to support the glass, when that glass is already supported by wood? Mullions and tracery are a natural and reasonable thing while the glazing is actually attached to them. They divide the area into widths narrow enough to stiffen the lead lights and iron frames; they form the stone rebated frame border with which the casements close. But when, as in the sash, the glass is carried in a wooden frame, and this frame works up and down in a wooden border, the whole thing has been already effected. There is no purpose for mullions, except that of hiding the real construction; their occupation is gone—they are a superfluity, a sham. We see, therefore, no defensible ground for the use of thin mullions in connection with sashes, meaning by thin mullions those which merely divide lights of which several are included beneath a single arch, and which have no other purpose than thus to divide them. If they carry the wall above, or even a solid tympanum, the case is different. They have then a practical use to serve; they become, in fact, small piers or columns, and are mullions no longer. The mixed style of the last few years has thus, we think, done rightly in rejecting tracery where sashes are used; but it has not been happy in finding a substitute. Its only idea, in the great majority of cases, has been that of a round-headed aperture, very broad, very low, and very ugly. Is there, then, some transcendent virtue in a wide semi-circular sash, which totally outweighs all considerations of beauty? Every one knows, on the contrary, that nothing can well be worse. Its upper part is so rickety and troublesome to close that it has even become the custom to make it square inside, though it appears round without. It really seems as if this dumpy meeting-house window had its ugliness tolerated for the sake of its inconvenience; it is hard, at any rate, to see why else it is endured and perpetuated.

Take another Gothic feature which this style omits, the arch moulding. In a brick building, and many of the buildings in question are of brick, elaborate mouldings are somewhat out of place. To be true in curvature they must usually be rubbed, not formed in the clay before it is burnt; and they thus become too costly for common work. They are replaced, in a great deal of this hybrid architecture, by colored voussoirs and patterns; and only in a minority of cases with a good result. These patterns, it is true, while they are fresh and bright, contribute something to the showiness of the design. They give importance, for a time, to the arches; but they do this in a far less satisfactory way than the details which they replace. They do not repeat the beautiful curves of the window-head, and enhance their beauty by delicate gradations of light and shade; they are totally dis-

connected forms—patches of applied surface decoration—not decorated features of construction. The result is that the eye soon wearies of them. Their effect, perhaps, is not in all cases to be rejected; we may be willing now and then to adopt them as part of the architect's *repertoire;* but we shall do ill to accept them as a final and complete substitute for the magnificent arch-moulds of the Early Pointed period; and even such excellence as they possess they do not long retain. In our towns, at least, they fade before their designer's eyes, and in a very few years disappear entirely behind a veil of soot. After all, an arch recessed in square orders is a far more permanent and far more architectural production. If we cannot have mouldings, we can, at least, have a series of square arrises; we can have lines of shadow and contrasting lights—something to express solidity and thickness, rather than a mere surface coating of red and yellow.

Another Gothic feature abandoned by this eclectic school is the high-pitched roof. For this there may be several motives, of which a chief one seems to be the saving of thought and invention. Steep roofs cannot well have very wide spans, or they rise too high, present too much surface to the wind, and look awkward and unwieldly. Now, while it requires care and skill to cover a large area by means of several moderate-sized roofs, anybody can manage it within reasonable limits in a single span. All that is necessary is to look in Tredgold's "Carpentry," or some similar book, for the form and scantling of the trusses, to stretch them across from wall to wall, to fix on them the usual apparatus of purlins and rafters, and to finish off with the usual pyramid of slating appropriate to what is known as a "substantial family residence." It is true that by a little contrivance the trusses might have been dispensed with, and a far better house built for somewhat less money; but as the proprietor is satisfied with it as it is, this is a matter which concerns no one. Another thing which has kept the flat-pitch in favor is doubtless the idea that there must be a waste of room where the angle is steeper. On one supposition, indeed, this must undoubtedly be the case, if it is an absolute necessity that all rooms should have horizontal ceilings. If a level surface of plaster overhead is really a first requisite of civilized life, then, indeed, the inside of every roof must be chiefly wasted, and it is natural to keep all roofs as low as may be. But if, on the contrary, it is a relief rather than an annoyance to escape from the box-like cells in which we pass our days into any apartment which has a structural and distinctive form, then there is no reason why some of the pleasantest chambers in the house should not occupy the space which is now neglected. We can easily make the construction fire-proof; we can render it as impervious to heat and cold as any part of the dwelling; and so far the high-pitched roof has more advantages for us than it had even for those who first introduced it. But it is not always for practical reasons, either real or supposed, that this feature is set aside. Quite as as often its exclusion seems to be only one part of a system—one development of the general idea on which the designers of the half-and-half style act. Their aim—or that, at least, of many of them—seems to be the production of a horizontal style free from the untruthfulness of the modern Classic, and their low roofs, like many other of their details, are adopted simply because their character is a horizontal one. This general aim, then, even more than the separate details, is what needs to be examined. Ought our modern style to have a strongly marked horizontal character? If not, the members of the school in question are on the wrong tack; for it is precisely this character which they seek to retain, while working to a considerable extent on mediæval principles. Without indorsing their practice, it is easy to feel a certain amount of sympathy for it. Remembering the absurd and exaggerated verticality which some quasi-Gothic designers of the day affect, large allowance should be made for the inevitable reaction. Looking, for instance, at the "Decorated" chapel of the period, with its wiry buttresses and pinnacles, and gablets all running up to seed, one cannot be very severe on the men who say, "Come what may, we will keep clear of such frippery as this; our buildings, good or bad, shall look like buildings, and not like confectionery ornaments on a Twelfth-cake." It is enough, for the moment, to make all verticality an abomination, and to drive us into an approval of heavy entablatures, and vast, overshadow-

ing eaves. But reason shows a way between the two. On the one hand, our town architecture must, by its nature, have a considerable number of horizontal lines. The mere division of houses into separate floors is of itself enough to produce them. There will inevitably be level ranges of windows, tier over tier, and to make them look like long vertical openings would be both untrue and unsatisfactory. Keep, then, those horizontal features for which there is a reason; display them as far as they exist; but do not add others which have neither purpose nor reality. The enormous cornice, for instance, which projects from the wall near the top of these mongrel structures, is quite uncalled for and unnecessary. It is not even an eaves cornice; it is a thing stuck against the parapet with no legitimate excuse whatever. Far better show the real construction, here as elsewhere; let the parapet announce itself, if there is a parapet, and decorate it instead of concealing it. Let the roof and the chimneys show themselves, and since their tendency is a vertical one, let it appear so. The very habits and customs of English society point to picturesqueness in our streets. We cannot have uniformity, for uniformity implies minute rules and regulations which would not be tolerated in this country for a moment. We cannot carry out the horizontal principle as the main one in our street architecture, with any success, until everyone is bound to build with stories of the same height, with cornices of the same section, with roofs of the same pitch, with doors and windows, even, of the same, or a closely similar pattern.

Till all this is enforced by law, every frontage must take care of itself; and the only choice is to give it a picturesque sky-line or a flat one. Now nothing is less interesting, has less merit of any kind, than a row of flat-topped house fronts of all sorts of heights and sizes, bobbing up and down, and looking as if they ought to have been uniform, but could not manage it. The most Classic of Classic architects cannot admire them as a whole, for they spoil each other; few things are more offensive than an attempt at regularity which does not succeed. If we could keep our street fronts as even as a line of the Guards on parade, it might, or might not be well to do so; but since we can get them in no better trim than Falstaff's ragged regiment, the only course is to break them out of order at once. Affecting no regularity, they may easily become picturesque; all that is wanted to this end is to let them follow their nature. And so, fully agreeing that a very vertical style is not the style for our towns, we are equally sure that an affectedly horizontal one is out of place there. The true medium will be found by keeping close to realities, by letting ranges of windows run straight when there is floor above floor compelling them to do so, but by allowing the roofs to break into hips or gables or dormers, just as may be most convenient and most beautiful.

We might go on to any extent criticising the other details which are retained or omitted in this composite manner of building, and might point out, if they really need pointing out to any one, the glaring discords which are produced by mixing up the peculiarities of two opposite architectural systems. But believing the general principle involved to be a mistake, there is no need to insist further on subordinate questions. The great want for modern purposes, as we conceive, is not a style whose leading features are rigidly uniform and horizontal, however much liberty such a style may allow in minor details. It is rather one which is picturesque by nature, though it submits to restraint where restraint is necessary—one which follows and expresses the actual character of the buildings to which it is applied, being horizontal where they are horizontal, and vertical where they are vertical. And it is likely to be arrived at, not by mixing up two quite distinct and incongruous types, but by selecting that one which seems most nearly to fulfil the conditions, and modifying it gradually and thoughtfully in the required direction. Hybrid races are rarely permanent, and the hybrid style of our modern buildings is not likely to prove an exception to the rule.

STREET RAILWAYS IN MELBOURNE.—An application has been made to the Melbourne City Council, by Mr. M'Millan, for authority to introduce street tramways into that city. The matter was referred to the Public Works Committee of the Council.

THE KEOKUK AND HAMILTON BRIDGE OVER THE MISSISSIPPI RIVER AT KEOKUK, IOWA.

From the "Journal of the Franklin Institute."

STATEMENT OF THE PUBLIC TEST OF THE STRUCTURE.

This bridge was tested May 18, 1871, for Mr. J. Edgar Thompson, President of the Pennsylvania Railroad Company. The tests were made under the direction of Mr. Henry Pettit, Civil Engineer, Construction Department, Pennsylvania Railroad, and all facilities for making them satisfactory were kindly furnished by Mr. George S. Smith, the engineer of the bridge, resident at Keokuk, who has had charge of the work at the bridge site from its commencement to its successful completion.

The designs for the superstructure were furnished by Mr. J. H. Linville, C. E., the drawings being carefully worked up under the direction of Mr. M. Benner, at Pittsburgh. The superstructure was made and erected by the Keystone Bridge Company, of Pittsburgh.

Commencing at the west or Keokuk end of the bridge, the spans are located as follows: Pivot span, total length of one truss, centre to centre of end posts, 376 ft. 5 in.; opening under each arm of 160 ft. measured on the square; 2 spans, 253 ft. 6 in.; 8 spans varying in length from 148 ft. 4 $\frac{3}{8}$ in. to 161 ft. 7 in.; total length, back-wall to back-wall on bridge seats, 2,192 ft. It is a through bridge built on a skew of 17 deg. 15 min., with a distance between the two trusses of 21 ft. 6 in. It carries a single line of railway track and two tramways for local traffic, the track being placed in the centre, between the tramways. On each side of the bridge, outside of the trusses, are foot-walks, 5 ft. wide, protected by light and substantial iron lattice railings.

When making the test the level and rod were in charge of Mr. E. H. Worrall, Engineer of the section work, and Major A. H. Burnham, U. S. A., Engineer in local charge of the Des Moines Rapids Improvements of the Mississippi River near Keokuk.

The load used in making the tests was a train made up of five engines from the Des Moines Valley Railway, with their tanks and boxes full.

The following table shows the composition of this train.

ENGINES.	Total length engine and tender.	Weight of tender.	Weight of engine.	Total weight.
	ft. in.	tons.	tons.	tons.
No. 1	39 0	16	26	44
" 19	41 7	20	31½	51½
" 22	42 5	20	31½	51½
" 20	41 7	20	31½	51½
" 3	40 5	18	27	45
Totals	205 0	....	....	243½

This load was placed so as to cover one-quarter of the span, when the deflections of the span were taken at the centre and quarter distances. The span was then loaded ½ of its length, then ¾, and finally its entire length. The deflections being taken each time at the same three points. Afterwards the permanent set was observed. All the lengths of spans given are the distances from centre to centre of the end posts.

Pivot span (the largest yet constructed.)

Total length of one truss..... .....376 ft. 5 in.
Arched upper chord. Depth of truss over drum..... 35 " 0 "
Depth of truss at ends..... 27 " 9 "

Load of 95.5 tons on the east half of the east arm = 1.07 tons per foot lineal.

East arm of span.

Deflection of the east half..... .1-8 in.
" at the centre .....15-32 "
" of the west half..... 3-32 "

West arm of span.

Deflection of the east half.....3-32 in.
Rise of the centre.....3-32 "
" of the west half.....3-64 "

Load of 178.5 tons covering entirely the east arm = 1 ton per foot lineal.

East arm of span.

Deflection of the east half.....23-32 in.
" at the centre.....15-16 "
" of the west half.....23-32 "

West arm of span.

Rise of the east half..... 1-32 in.
" at the centre..... 1-8 "
" of the west half..... 3-65 "
Strain of compression at centre of upper chord of east arm .....6,752 lbs. per sq. in.
Strain of tension at centre of lower chord of east arm .....7,063 lbs. per sq. in.

Load of 103 tons on east arm and 96.5 tons on the west arm = .56 tons per foot lineal.

East arm.

Deflection at the centre.....23-32 in.

West arm.

Deflection at the centre.....15-32 in.

Permanent set after all load was removed.

East arm.

East half..... 1-80 in.
Centre..... 1-27 "
West half (next the drum)..... 1-16 "

West arm.

East half (next the drum)..... 5-32 in.
Centre..... 1-80 "
West half..... 1-27 "

Time of turning the pivet the entire opening of 72¾ deg.

With the engine .....2 minutes.
With six men..... 2 min. 30 sec.

Span No. 3.

Length 253 ft. 6 in. Height of truss 27 ft.

Ratio of height to length = 1 to 9.388.

Load of 68 tons on the east quarter = 1.07 tons per foot lineal.

Deflection of the east half..... 5-32 in.
" at the centre..... 1-8 "
" of the west half..... 1-27 "

Load of 147 tons on the east half of span=1.16 tons per foot lineal.

Deflection of the east half.....19-32 in.
" at the centre.....25-32 "
" of the west half.....13-32 "

Load of 198.5 tons on the east three-quarters of span = 1.04 tons per foot lineal.

Deflection of the east half .....31-32 in.
" at the centre .....1 3-8 "
" of the west half.....29-32 "

Spread of lower chord measured at the roller box = 3-16 in.

Load over the entire span of 243.5 tons = .96 tons per foot lineal.

Deflection of the east half.....1 5-32 in.
" at the centre.....1 11-16 "
" of the western half.....1 1-4 "

Spread of the lower chord measured at the roller box ¼ in.

Strain at centre of upper chord, compression = 8,962 lbs. per sq. in.

Strain at centre of lower chord, tension = 9,251 lbs. per sq. in.

Span No. 2.

Length 253 ft. 6 in. Height of truss, 27 ft.

Load 243.5 tons over the centre span =96 tons per ft. lineal.

Deflection at the centre of span = 1¾ in.

Permanent set after load was removed 3-64 in.

Span No. 4.

Length 159 ft. 9⅛ in. Height of truss 21 ft.

Ratio of height to length, 1 to 7.6.

Load of 44 tons on the east quarter = 1.1 tons per foot lineal.

Deflection of the east half..... 9-32 in.
" at the centre..... 5-16 "
" of the west half.....19.32 "

Load of 95.5 tons on the east half= 1.19 tons per foot lineal.

Deflection of the east half..... 7-16 in.
" at the centre.....23-32 "
" of the west half..... 7-8 "

Load of 147 tons on the east three quarters of span = 1.22 tons per foot lineal.

Deflection of east half..... 2-8 in.
" at the centre.....1 "
" of the west half.....1 3-6"

Load of 153 tons over the entire span =905 tons per foot lineal.

Deflection of the east half ..... 25-32 in.
" at the centre.....1 5-32 "
" of the west half.....1 5-16 "

Permanent set after the load was removed at the centre of span = ¼ in.

THE "Observer" contradicts the rumor that there is an idea of placing the Mint on the Thames Embankment. The site which the Government proposes to adopt for a new Mint is, it states, in Temple-lane.

THE TIMBERING OF TRENCHES AND TUNNELS APPLICABLE TO RAILWAY AND SEWERAGE WORKS.*

From "The Engineer."

Timber is required in constructing sewerage works, to support the sides of the narrow and deep cuttings required in building the drainage culverts and pipe drains, for centring, drainage purposes, and other special purposes hereafter mentioned. It is also required in tunnelling to support the sides of the shafts, and the roofs, and side walls of the headings; to carry the tramways, and for the construction of the long pump rods in the deep shafts. Also for centring, drainage, trunks, and other special purposes. The manner of framing and introducing the timber depends greatly upon whether the timbering is to be only temporary, that is to say, merely to support the ground in advance of the masonry, or whether, as in the case of headings for a tunnel, it is required to stand possibly for several years.

Secondly, on the description and quality of the timber to be used; *i. e.*, whether the timber is to be round, half round, or squared timber; and what sort of timber and what sizes of it are available. It is usual for temporary work, such as that first mentioned, to use the timber that is the cheapest, the most easily and most economically transported, and which is the most salable after it has served the temporary purpose required of it. If the timber is sufficiently good and strong for its work, no objection can be taken to such a course, but it is often a very short-sighted policy, as it is hoped to be shown presently. Before entering more particularly into a description of the timbering required for open cuttings for sewerage works, and for driftways, headings, etc., for railway tunnels, it will be well to set forth a few simple rules for carrying out such works of timbering generally. They are well known by all mining engineers, and most of them by any good practical miner. (1) All timber used should be of as hard and tough a nature as it is possible to procure for a reasonable cost. (2) All timber should be cut at the fall of the year, when the sap is down, and no timber ought to be used that has not had a certain amount of seasoning, having been kept either constantly wet or dry for not less than six months after it was felled. (3) All timber used should have been barked three months before using. (4) The best description of timber for shores, sills, posts, etc., is larch or fir; oak may be used occasionally to resist a great transverse strain. (5) The principal strain should in all cases be thrown as far as possible upon the end grain of the timber, or, in the case of waling pieces, sills, or sleepers, which should always, if possible, be of half round timber upon the rounded side of the timber. (6) All side pillars or side posts should be slightly oblique, forming with the head and ground sills the section of a truncated pyramid. The tenons of the pillars, etc., should be cut square, and the mortices in the sills at an angle to prevent lateral movement. (7) The timbers should be framed and fitted accurately; no spikes or bolts to be used to keep the timbers together; all wedging up to be avoided as far as possible, except in certain cases described hereafter. (8) All polling boards in headings, and the linings at the back of the curbs where square shafts are timber-lined, should be pointed and driven obliquely, each set to overlap the preceding one. (9) All shores to be fitted to drive from above, and never in any case sideways or horizontally. When half round timber is used for the waling, the ends of the shores to be slightly bird's-mouthed, to fit to the shape of the timber. (10) As large a bearing surface as possible to be allowed where the end of one timber takes a bearing upon the face of another timber. (11) When planks, battens, or other square timbers are used for waling pieces, they should be bedded in the sides of the excavation at a slight angle, so that when the shore, cut to the proper angle, is driven down from above, it will always take a fair bearing over the whole of its surface. (12) Adjustable gauges to be provided for taking the exact length and exact angle of ends of the timber required. (13) No timbers require to be fitted in their places more tightly than to take a fair bearing. If any strain is shown

* Paper read before the Society of Engineers, by Mr. CHARLES TURNER, of Southampton.

upon them they will be tightened far better and more in the direction required than by any artificial means that can possibly be used.

First, as to timber in open cuttings or for sewerage work. Most of these works are executed either in large towns or in the neighborhood of them, and the timber used to support the sides of the excavations is either such as can be found in the place or can be most easily conveyed to it—fir scaffold poles, cut up into lengths, being used for the shores, and the cheapest description of battens or planks that can be procured, for the walings. In many cases these are only used for form's sake, and might readily be dispensed with. The common practice is to introduce tiers of battens, about 4 ft. or 5 ft. apart in depth, with round poles of from 4 in. to 6 in. diameter for shores. These are almost always driven sideways into their places, and even if well cut and fitted have but a comparatively small bearing upon the batten which forms the waling piece. If the cutting is dry, these shores frequently become loose and drop down, as there is seldom any upright or support under them. In many cases this arrangement proves sufficient, as no timbering is really wanted ; but when there is really a pressure exerted against the timber, the waling planks or battens are very apt to split, from the shores being driven in sideways, and therefore bearing on a very small surface of the timber. If battens are used in the above manner it is much better to cut the excavation to a slight batter, and to let the battens or planks in parallel to the face, and to drive down the shores from above sufficiently tight to give the batten a firm bearing against the sides of the excavation. The lower tier of battens should be strutted up from the ground, and uprights should be placed at intervals between the tiers of battens, especially under the joints. When half-round timber can be procured it is generally preferable to the battens, as it has less tendency to split. In that case the flat side of the timber should be placed against the side of the cutting and slightly let into it, and the end of the shores should be slightly bird's-mouthed out to fit the round side of the timber, and should be driven down from above. If the ground worked through is of a very shifting nature, such as thin strata of sand or clay, with water, it is often necessary to close-timber the cutting. In this case planks should be placed upright at intervals of from 5 ft. to 6 ft., with horizontal planks behind them, one upon the other; the usual round shores being introduced between the planks, which must always be laid at a slight angle, so that by driving down the shores from above the whole will be wedged firmly into its position. When the ground is very insecure, the upright planks can only be driven in short lengths, the one being made to overlap the other. Of course a system of timbering comparatively so complicated should not be used unless absolutely necessary, and in many cases where there is sufficient depth of roof it is better to carry on the excavation in short lengths and tunnel in between. But there are cases where tunnelling cannot be adopted, and it is better to go to any reasonable expense in timbering rather than to risk life. Besides the above reasons, in many instances it is absolutely necessary to leave the timber in until the ground has become thoroughly consolidated. Unless such timbers are of the proper size, and have been well framed together, such a precaution is worse than useless, and it gives a fancied security which does not really exist.

There is another use of timber, which cannot be said to be confined strictly to cutting trenches for sewerage work, as it is applicable in all cases where masonry is carried on in deep excavations. It has been found more advantageous, instead of carrying down the mortar in hods to supply the bricklayers, to construct small trunks 5½ in. sq. internally and about ¾ in. thick; they are made out of stuff procured by putting two cuts through a batten, and fitted with hopper heads. The lower ends are easily shifted, so as to deliver on to the mortar boards, the trunk being slung by a rope attached to short shear legs across the cutting. The mortar heap is made close by the cutting as the work proceeds, and one man filling the mortar into the hopper heads of 2 trunks can keep 4 bricklayers going instead of 2, or even at times 3, hodmen, who would otherwise be required, temporary shores and struts being used in some cases until the permanent shores can be driven. Where the ground is of the nature of running sand, and can only be excavated

in very shallow lifts or stages, the excavation may be carried on after the manner in which square shafts are sunk and timbered in some of the German brown coal mines, upright pieces of half-round timber, pointed at the ends, being first driven into the ground, in advance of the excavation, and inclining slightly inwards. Waling planks are fixed between these timbers, and supported in a temporary manner by short piles, until the shores are introduced and driven from above, as before mentioned, care being taken always to have uprights under the waling planks. A space, varying in width from 2 in. to 3 in., will be left behind the waling planks, into which should be driven planks, or battens, or half-round pieces of timber pointed at the ends, and which pieces must be gradually driven downwards as the work proceeds, as far as safety will allow, when another upright is driven down in front of the first in the same manner as already described, and shown in sinking short lifts through shifting ground, requiring to be close-timbered. Great additional strength is given to this mode of timbering by introducing long binders of stronger timber from top to bottom of the excavation, taking a bearing against all the walings and having independent shores between them. This plan has also a great advantage in deep cuttings, where lias stone lime is used. The sliding of the mortar down the trunk keeps it chafed up and soft, instead of its constantly getting stiff upon the mortar boards when carried down in hods. It is of such great importance that the timbers used in shoring should be accurately fitted, that simple adjustable gauges, which do not easily get out of order, will always pay for themselves, such as may be made for taking angles and splays, and also for taking dead lengths at the same time. Although there are great objections to using iron bolts, screws, or spikes, to frame shoring together, there are cases where iron may be advantageously used in connection with wood, where shores have to be taken down and replaced on the completion of each length of culvert. The ends quickly wear out, especially if they are driven horizontally, and the shores become too short. The plan was tried of shrinking iron hoops on to the ends of the shores, and was found to answer very well, and that there was a saving of one-third of the timber used in shores, even in a length of 100 yards of culvert. Where the pressure is very great upon the shores they are very apt to split the waling, unless they are cut very accurately and are of the full size of the plank. It has been found of advantage to provide a few wrought-iron clamps to use in such exceptional cases; they are fixed at the back of the shores. There is one more way in which iron may be used with advantage in connection with timber for shoring. It is frequently necessary to introduce additional shores at the bottom of a deep excavation for sewerage work, or to change the position of those which are fixed, to make room for the masonry. It is often very difficult to drive such additional shores into position, so that the proper pressure may be thrown upon them without disturbing several others. It is proposed to effect this object by making use of a double shore capable of adjustment in the length, and constructed in the following manner: A piece of round timber 7 in. in diameter, is hooped at both ends with strong wrought-iron hoops, made from $\frac{3}{8}$ iron 4 in. broad. A groove is then cut down the centre of the piece of timber 1 in. wide, as far as the hoops at each end, with 2 cross grooves in the centre $\frac{1}{2}$ by $\frac{1}{4}$. Folding wrought-iron wedges, with projecting ribs to fit the cross grooves, are then introduced in the centre, and driven up till the timber is sprung apart about 2 in. or more, as the case may be, according to the length of the shore. Two other rings made of the same sized iron are then slipped over the ends of the timber, sufficiently large to go nearly as far as the centre wedges. They are to be driven sufficiently tight to hold them firmly in their positions; the shore is then ready to fix in place. When in place the wedges are to be slackened, and the spring of the timber will cause the shore to fix itself tight without any hammering or wedging. When so fixed, the loose rings are to be driven up against the wedges in order to prevent springing if an unusual strain is thrown upon the end of the shore. When the shore requires to be withdrawn, the wedges are to be driven up again, and in so doing the loose rings are driven back, and the shore being shortened is easily removed. Cast-iron friction rollers working on wrought-iron pins are sometimes introduced with ad-

vantage at intervals, instead of the wood rounds to the ladders used for conveying materials in deep sewerage trenches; they should of course be rather larger than the rounds. By carrying an endless rope round these rollers bricks may sometimes with advantage be lowered down in boxes, instead of being carried down in hods. There are many other minor uses for timber for sewerage work, such as centring, put together in pieces when common centring cannot be withdrawn, temporary drainage trunks, and other items, which need not be particularly described.

Secondly, as to the use of timber in tunnel headings. The timbering, when the ground is tolerably firm, generally consists of 2 side posts, which are let 4 in. or 5 in. into the bottom. They should be inclined towards each other and framed into a head sill. When the ground is soft or shifting, the side posts should stand on sole plates of half-round timber, or short pieces of plank about 1 ft. 6 in. long. If it is of a still more shifting nature, it is better to frame the posts into ground sills, either let into the bottom or framed together in a complete system of longitudinal and cross sills. When 2 sets of frames have been introduced at distances of from 4 ft. to 6 ft. apart, as the case may be, they are lined at the back with boards or planks, either at intervals or close together, as may be required. Pieces of board, pointed at the end, commonly called staves, are then driven above the head sill in the direction of the next frame; these should always be driven with a certain divergence outward, in order to make room for the introduction of the following set. This divergence is obtained either by cutting the board wedge-shaped, or by driving in slight temporary keys from the front between the boards and the head sill; or, better still, by introducing a lintel above the head sill, which is wedged up by two or more hard wood wedges against the ends of the boards. It is sometimes necessary to drive these boards also at the back of the side posts and under the sills, forming a close timbering, having the section of the frustrum of a pyramid. It is often also advisable, in order to assist in obtaining this divergence, to fix a third set of framing, rather larger than the others, in front of the second set, over or outside of which the boards are driven. The second set of staves is driven forward, in like manner overlapping the others to the extent of 5 in. to 6 in. If the stratum contains much water, it is necessary to secure the face as the work proceeds. It is better in that case to proceed in steps by fixing short planks against the face of the work, and driving shores between them and the next frame, and if necessary, strutting the frame against the one behind it. The poling boards and the boards forming the lining behind the side posts are then driven forward by degrees, sometimes only a few inches in the course of a day. Various temporary means of strutting and shoring the face are adopted, but these are so numerous, according to circumstances, that it is impossible to give any general rules for constructing them. Experience and presence of mind are the principal guides to be relied on in such cases. Where it is necessary to carry a tramway through the heading, the sleepers should be laid independently of the ground sills. The drainage from a heading should be carried in wood trunks laid upon the ground sills, and under the cross sleepers carrying the tramways. These trunks should be made with a bottom and two sides tied together by cross pieces, dovetailed into the sides of all the joints and intermediate ties, about 4 ft. apart. The top should be loose, formed of short pieces with ledges under, of such a length that they may drop easily into their places, and may be lifted for the purpose of cleaning out the trunk.

In enlarging the tunnel from the section of the heading to the full size, very little timbering is required in an ordinary way beyond the centring, as the masonry in all cases should immediately follow the excavation as it proceeds. There is always, however, a certain space to support in advance of the centring, to allow room for the men to work in. This will often carry itself; at other times it is supported by short ends of boards, or planks resting on the masonry, and either shored or strutted against the face. A better plan would be to make use of an inner and outer centring, the outer slightly overlapping the inner, and being strutted up from it. The front face of the inner or principal centring should stand almost fair with the face of the outer centring,

but must not overlap it much, in order to give room for filling in round the outside of the arch. The two sets of centring should be moved forward gradually as the work proceeds, and wedged up when in their places. The uprights should be of round timber; all tightening up should be done with wedges driven between the double plates. In some cases it is very desirable to construct the centring so that it may be taken to pieces. A trussed centring in 3 thicknesses is the most convenient description of centring for this purpose. The outside segments of the centring are cut in the usual form, and are jointed on the uprights; the uprights are shouldered to support the middle piece. The uprights and segments are tied together by wrought-iron loops, which are riveted to the one segment, and, passing through a mortice in the middle segment and the outside segment on the other side, or the opposite upright, are keyed firmly against the upright or opposite segment by a hard wood wedge driven through the loop.

Then as to timber in shafts. In some cases a double curb of 3 in. plank, with the cross joints properly broken, is laid upon the ground, and, the masonry being built upon it, it is gradually sunk into the ground, by excavating out the inside, and under the curb; various descriptions of iron bond being used to tie the masonry. For smaller shafts, a common well curb is used, rather more strongly constructed than usual. Where timber is plentiful, and the conveyance of materials difficult and expensive, a square or rectangular shaft may be sunk, and timbered in a similar manner to the shafts adapted for the mines in the Hartz Mountains. A strong curb of round timber is first laid, the timbers being halved together and slightly bird's-mouthed, in order that they may fit to the rounded sides. When the ground is very full of water, or otherwise insecure, the curbs are laid one upon the other. At other times they are kept at variable distances apart, and are sometimes lined at the back with 2 in. planks, but generally they are lined at the back with boards pointed at the ends, driven to a certain batter by the same means reversed as those described for driving headings, one set of boards always overlapping the next.

The long pump rods for deep shafts are generally of square timber, scarfed and bolted together, but where tapering sticks of round timber are readily available they will make an equally strong and much lighter and more economical pump rod. There are many other purposes for which timber is used in connection with tunnelling, as, for instance, the windlasses and horse whims for raising the stuff excavated, the ribbles or tubs in which it is raised, and the various timber erections and other buildings which are required in connection with the pumping and hoisting apparatus. These, however, vary so much that it would not be possible to describe them properly within the limits of an essay. It is sufficient to say that all framing should be well and strongly put together, and well tied with iron where it is in the open air, and all wearing parts should be of iron, or, if that is not possible, of very hard wood; and nothing should be so complicated as to prevent an intelligent miner from taking it apart and putting it together again. It is not for a moment supposed that anything new has been brought forward in the foregoing observations. An attempt has only been made to collect together a few memoranda from personal experience as a railway and sewerage engineer and contractor, and also the results of the information obtained while superintending some mines and furnaces in the Hartz Mountains, the timbering of which was carried out under the direction of a very intelligent and experienced German mining captain. Several of the modes of using timber above described were there executed under his superintendence at the suggestion of the author of this paper.

We hear the Prussians are about to abandon the needle-gun, and are apparently hesitating between the choice of the Chassepot, of which they have half a million taken from the French, and the Werder rifle.

The Select Committee on Steam Boiler Explosions, of which Mr. Hick, the member for Bolton, was chairman, the "Post" has reason to believe, reported by a considerable majority against official inspection.

THE EAST RIVER BRIDGE.

SECOND ANNUAL REPORT OF THE CHIEF ENGINEER (COL. WASHINGTON A. ROEBLING) OF THE NEW YORK BRIDGE COMPANY.

To the Hon. HENRY G. MURPHY, *President:*

SIR,—I have the honor to present the following report of operations on the East River Bridge during the past year:

At the date of the last annual report, made June 5, 1870, the first foundation stone had been laid on the Brooklyn caisson, which was still afloat at the time, rising and falling with the tide. During the year that has elapsed the foundation of the Brooklyn tower has been successfully completed, notwithstanding numerous drawbacks, the caisson being sunk to a depth of 45 ft. below high water. The tower masonry is now being carried up, and has reached a height of 25 ft. above high tide.

The first material was brought up from the caisson by dredgers, July 5. By December 18, it rested upon 72 brick piers which had been built for its reception within the air chamber. The filling up of the air chamber required two months and a half, being finally closed March the 11th, nearly one month of which time was consumed in repairing the damages to the caisson caused by the fire of December 2, 1870.

The laying of masonry practically ceased in the middle of December, a rigorous winter forbidding its resumption until the middle of March.

Inasmuch as the Brooklyn caisson is by far the largest structure of its kind ever sunk, although not the deepest, and since the bulk of the material encountered was next to solid rock in difficulty of removal, it may be of general as well as professional interest to enter into a more detailed account of the operations.

EXCAVATION OF MATERIAL.

While the caisson was still rising and falling with the tide, the hours of work inside the air chamber were confined to low water. Three courses of masonry were required to weigh it down permanently against the buoyant effect of the inflated air chamber. The force of workmen inside was gradually increased, their principal occupation being the removal of sharp-pointed projecting boulders, which threatened to damage the supporting frames and edges of the caisson, as the latter settled down on them with a crushing force at low water.

Although the preliminary dredging had arrived at an uniform level of 18 ft. below high water, it was found that there were enough boulders overlooked to reduce this level to 16½ ft. Several weeks were spent in removing them and levelling off the ground under the shoes to the 18 ft. level before the excavating machinery was ready to operate. In the pits under the water-shafts were several large boulders below the water level, upon which the lower edge of the water shafts rested. These were a source of considerable anxiety until removed by the tedious operation of clipping them to pieces with long steel bars.

The material now became sufficiently exposed to enable us to arrive at the conclusion that it was of a very formidable nature, and could only be removed by slow, tedious, and persistent efforts. This had indeed been the expectation from our previous experience in the dredging and blasting under water. But the work being under water, and, therefore, out of sight, did not impress us so much at the time, as now, when we were face to face with it.

NATURE OF MATERIAL.

In the two middle chambers of the caisson the ground was composed of trap boulders, large and small, packed together so closely as to touch, the space between being filled by a natural concrete, composed of decomposed fragments of green serpentine rock. The boulders were coated with this natural cement, which adhered so strongly as to defy the action of steel wedges. A steel-pointed pick had no effect whatever. It was only by using a steel-pointed crowbar, and driving it in the crevices with heavy sledges, that any of this material could be piled up and removed. In chambers Nos. 1 and 2 adjoining the Fulton Ferry slips, the boulders were equally as large and as numerous, but the cementing material was clay and gravel, not so hard as the serpentine concrete. In chambers Nos. 5 and 6, however, this hard ridge rapidly fell away, giving place to several feet of mud, under-

laid by a stratum of unctuous blue clay, and continuing soft in the north corner of No. 6 chamber for a depth of 40 ft., as had been indicated by previous soundings.

It was evident, therefore, in order to have a uniform foundation over the entire area of the caisson, it would be necessary to go down fully 40 ft., and this depth was extended to 45 ft., so as to have the timber entirely below the iron bed.

The area of the caisson, 17,000 sq. ft., is so large that no uniform stratum over the whole surface would be likely to be found anywhere within this drift formation at any moderate depth below the water level. No better foundation could have been wished for than that found in chambers Nos. 3 and 4, provided it had extended all over.

Nine-tenths of the boulders were trap, transported hither during the drift period from the palisades of the Hudson. Owing to their hardness, they had resisted the wear of time the longest. They occurred of all sizes, from 1 cubic foot up to 250. Boulders of quartz and gneiss rock occurred more rarely. Two large boulders of red sandstone were also found. The softer varieties of rocks had all been worn down to pebbles. A collection made of the various specimens encountered during the descent of the caisson presents a complete series of the rocks found for a hundred miles to the north and north-east of Brooklyn.

LOWERING THE CAISSON.

The adoption of a regular system for lowering the caisson uniformly was a matter of much experiment at the beginning. No amount of pressure could force the bearing surfaces of it through the ground without crushing the cast-iron shoe at the cutting edge, or smashing the bearing frames. A few days' experience demonstrated that fact. On the contrary, it became a matter of primary importance to dislodge all boulders in advance before the shoe or the frames came to a bearing upon them.

All this work had to be done under water, because there was usually along the shoe a trench filled with water communicating with the water outside, and this trench was connected with cross trenches under the frames, which in time supplied the large pools around the water shafts.

The finding of these boulders in advance was a laborious, disagreeable, never ending task. Its performance fell entirely upon the engineering staff in the caisson, Col. Paine and Mr. Collingwood, and the principal foremen, Messrs. Young and Clark. The perimeter of the shoe or cutting edge measures about 540 ft.; adding to this the five frames of 102 ft. each gives a total length of 1,050 lineal feet of bearing surface, every inch of which had to be carefully probed under water twice a day with a steel sounding bar, and the proper conclusions drawn as to the best means of moving the rocks, hard pan, and other material found. Each shifting gang of laborers had to be informed anew whenever their turn of work came on. Being under water, this, besides, became a matter of memory and not of mere eyesight. Moreover, a settling of the caisson of 6 in. or a foot would bring to light an entirely fresh crop of boulders in new positions, and very often half without and half within the caisson.

The shoe being of necessity unsupported, it was left for the frames to support so much of the weight of the caisson as was not balanced by the air pressure.

The first attempt in the operation of lowering was to leave small pillars of earth under the frames, about 3 ft. square, and from 6 to 8 ft. apart, the intervening earth being taken away, and forming part of the trench. These pillars were to be then uniformly undermined, and the caisson lowered in that manner. It was soon found that the pillars usually concealed the head of a large boulder, which required their premature removal. Again, the water would wash them down, and still oftener the laborers in adjacent chambers not working in unison, would undermine them and destroy their effect.

The plan next adopted worked very well, and was pursued to the end. It consisted in supporting the frames every 8 ft. on two wooden blocks, 12 in. square and 2 ft. long, one above the other, with four stout oak wedges interposed between the blocks and bottom of the frame. A continuous trench, 2 ft. deep and 4 ft. wide, was thus maintained under the frames, giving ample working room for the removal of boulders. Whenever the shoe had been cleared out for 6 in. in advance, these wedges were then loosened with sledge hammers, one by one, and

frame by frame, until the caisson slowly settled. Then either new blocks were put in of a smaller size alongside, or, as was usually the case, they were allowed to crush. Very often a sudden descent of the caisson would crush half the bearing blocks, until brought up by the shoe. The operation was analogous to the splitting out of blocks and wedges during the launch of a ship.

The bottoms of the frames were originally 2 ft. wide. This width was found too great to allow of the easy removal of rocks from underneath. They were, therefore, cut down to a width of 1 ft. The lower ends of the frames were likewise cut loose from the side of the caisson, to allow more easy access to the point of the junction. This reduction of bearing surface added materially to the risk in case of accident.

REMOVAL OF BOULDERS AND EARTH.

Boulders occurring inside of a chamber were usually left undisturbed until the caisson had sunk sufficiently to enable us to attack them above the water level. They were then split into manageable blocks by plug and feather.

Boulders under the frames presented more difficulty. The ground in which they were embedded was cut away with steel bars as much as possible; they were then drilled under water and a lewis inserted. The appliances for pulling them out of their beds were various. Those first in use consisted of double sets of block and tackle, aided by winches and crowbars, with a gang of 30 or 40 men hauling at the ropes. All this force was frequently found ineffective; the strain required being usually from two to three times the weight of the stone. The cause of this lay in the air pressure, which amounted not only to the 15 lbs. of atmospheric pressure, but the caisson pressure in addition, the whole being effective by reason of the water-tight clay in which the stone was imbedded. As soon as the boulder was loosened in its bed to a slight extent, it soon followed. These hauling arrangements were replaced after a time by three of Dudgeon's hydraulic pulling jacks, two of 10 tons and one of 15 tons capacity. This proved to be a very effective instrument. They were usually attached to heavy screw bolts let into the roof of the caisson, and formed part of a chain leading to the stone. Many boulders, however, resisted the united efforts of all three jacks.

The removal of the hard earth could be effected at the beginning only by the use of steel-pointed crowbars driven in with sledge hammers. Under water the blow of a pick has but little effect. The long-handled, round-pointed shovel answered best for lifting the material out of the water into wheelbarrows.

After the caisson had been lowered about 2 ft. it became possible to build dams around the trenches under the frames and bail out the water. This enabled us to see the work at hand, and materially lightened the labor attending it. These dams were shifted from trench to trench, care being taken always to leave an open trench leading to the water shaft.

The removal of the water from the trenches was accomplished partly by hand bailing, then by air siphon pumps and steam siphon pumps, and finally by compressed air itself, throwing it entirely outside of the caisson through pipes introduced through the timber and masonry.

To work the air siphon a complete system of $1\frac{1}{2}$ in. pipes was placed in the caisson with suitable connections. Through these pipes air was introduced under a pressure of 60 lbs., one of the main air pumps being set apart for that purpose. The pump was constructed on the principle of a Giffard injector, and as the duty required was simply to lift the water from 3 ft. to 4 ft., it was expected to work well, but it never did. Steam was then introduced in place of extra compressed air through the same pipes. This answered the purpose admirably, draining the trenches in a short time. It afforded an ocular demonstration of the operation of a Giffard injector, since the caisson simply corresponds to the interior of a huge boiler, and steam, under the same tension as the caisson pressure, produced the desired result. One circumstance, however, led to its early abandonment. When the pump had worked a few minutes, the temperature would rise to 100 deg., driving the men from that particular chamber. Recourse was then had to a simple flexible suction hose, communicating with a pipe leading out of the caisson. The end of this hose was held in the water, so that about $\frac{3}{4}$ of it was sub-

merged. The compressed air rushing through the remainder of the opening kept the whole column of water in motion at a rapid rate. This mode is, of course, attended with a slight loss of compressed air, but it proved far simpler to raise the water 40 ft. out of the caisson than 4 ft. inside of the caisson. Soft mud and fine sand passed out readily with the water.

BOULDERS UNDER THE EDGE.

The occurrence of large boulders under the shoe proved to be the most serious obstacle to a rapid sinking of the caisson. As long as the water from without still had free communication with the air chamber, they had to be attacked under water, the most tedious part of the operation being the removal of the earth in which they were imbedded. When the stones extended more than 2 ft. or 3 ft. outside of the caisson no attempt was made to haul them in, but they were slowly chipped to pieces, until enough had been removed to enable the edge of the caisson to clear them.

As soon as the dredgers were at work, the excavated material was dumped around the outside of the caisson, with a view of stopping the ready passage of water under the shoe. This was effected after a time. Then, by building a clay dam around the boulder on the inside, and filling up the adjoining space with bags, it became possible to dig a comparatively dry pit underneath, into which it was tumbled, provided it was not too large.

Several boulders occurred which delayed all settling for 3 or 4 days at a time. In order to gain time, a special force of some 30 men was then organized, who worked only at boulders from 11 o'clock at night until 6 A. M., when the regular gangs came to work.

It may truly be said that the result of the first month's work was not very encouraging. We had a material to deal with which is difficult to remove, even under favorable circumstances, on top of the ground. The rate of descent had not averaged 6 in. a week, and the boulders were increasing instead of diminishing in numbers. To look forward to a rate of lowering of even 1 ft. per week seemed hopeless.

The work inside was rendered still more disagreeable by the frequent "blows," caused by the rushing out of the compressed air under the shoe. This would continue for several minutes, until a returning wave of inflowing water from some other part of the caisson would check it, leaving, however, a foot of water all over the ground for some time, until the air pressure drove it out, and the occurrence repeated itself. The trenches were usually flooded thereby and had to be pumped or bailed out incessantly. These flows were caused by change of the water level outside, due partly to passing steamboats, but principally to constant changes in the tide; the thick fog which accompanied them was always an indication that they were transpiring in some part of the caisson.

On the other hand we were daily gaining in experience. The workmen became more accustomed to the novel situation and more practised in the particular kind of work to be done, and the heaping up of a bank of earth around the outside led us to hope that when the caisson had sunk a few feet lower the conditions of air pressure and the general regimen of the caisson would become more equable, and, what was of more importance, the free access of water from without would probably be materially curtailed. These expectations were more than realized. In a short time water became as scarce as it had been plentiful before.

BLASTING.

When the caisson had arrived at a depth of 25 ft. below the water level, the boulders became so large and numerous as to compel us at last to resort to blasting. The idea of using powder had been entertained all along, yet our imaginary fears, supported by plausible reasoning, had prevented the attempt thus far. It was supposed that the effect of the explosion would produce a violent concussion in that dense atmosphere, rupturing the ear-drums of the men. Again, the effect upon the doors and valves of the air locks might be such as to endanger their safety.

The principal apprehensions were, however, in the direction of the water shafts. Here were 2 columns of water 7 ft. sq., and ultimately 45 ft. high, held in a critical balance by the pressure inside, the margin of safety being an immersion

of less than 2 ft. on part of the lower edge of the shaft in the pool surrounding it. The sudden explosion might rapidly depress the level of the pool and allow the air to escape underneath, which would be fatal both to the caisson as well as the men inside. Again, as regards blasting under the shoe and partly outside of it, it was feared that the explosion migh cause a vent outward, followed by a rush of air.

The result, however, justified none of these apprehensions.

First, a trial was made by firing a pistol with successively heavier charges, then small charges were fired off by a fuse, and soon blasting became an established system. The good effects were at once apparent in the lowering of the caisson from 12 in. to 18 in. per week in place of 6 in.

The first entry into the caisson was made with considerable misgivings, but none of our fears were realized.

The total settling that took place amounted to 2 in. in all. Every block under the frames and posts was absolutely crushed, the ground being too compact to yield; none of the frames, however, were injured or out of line. The brunt of the blow was, of course, taken by the shoe and sides of the caisson. One sharp boulder in No. 2 chamber had cut the armor-plate, crushed through the shoe casting, and buried itself a foot deep into the heavy oak sill, at the same time forcing in the sides some 6 in. In a number of places the sides were forced in to that amount, but in no instance were they forced outward. The marvel is that the air tightness was not impaired in the least.

The 9 courses of timber forming the sides of the air chamber were permanently compressed to the extent of 2 in., as was shown by protruding bolt heads and the shearing off of a number of diagonal bolts. The lower sills of the frames were also torn where they came upon boulders.

The weight of the caisson at the time was 17,675 tons. The air blew out so suddenly that this weight must have acted with considerable impact in falling through the space of 10 in. The bearing surface at the time was as follows: The 4 edges of the caisson, 550 ft. long and 7 in. wide, amounting to 322 sq. ft.; the 5 frames, each 100 ft. long and 1 ft. wide, resting on 12 blocks 1 ft. wide, amounting to 60 sq. ft., and giving a total of 382 sq. ft. to meet the above pressure. This at the rate of 46 tons per sq. ft.

But more than one-half of the shoe was undermined to a depth of 1 ft. or more, which reduced the practical bearing surface by nearly one half. At the commencement of the shock there was, therefore, a pressure of 80 tons per sq. ft., no allowance being made for impact, which may have doubled this rate. The caisson had settled 10 in. The shoe had buried itself so as to present a width of 12 in., and through the crushing of the blocks the frames were in many places resting bodily on the ground. The settling had, therefore, stopped when a bearing surface of 775 sq. ft. had been reached, giving a pressure of 23 tons per sq. ft.

As the caisson proceeded in its downward course, the disproportion between the dead weight above and the air pressure from below became greater and greater. For instance, on the 15th of November, the escape of air under the shoe was so strong that no more than 10 lbs. of air pressure could be maintained. The over-pressure entailed thereby was 12,240 tons. This was received by a bearing surface of 280 sq. ft., causing a pressure of 44 tons per sq. ft.

In order to meet this constantly increasing overweight, a large number of additional shores were introduced into the caisson. They rested upon a block and wedges, and supported a cap spiked against the roof. The presence of these shores added considerably to the labor of lowering the caisson, and diminished the available working space otherwise. They gave, however, a positive assurance against any possible crushing weight from above, and could, moreover, be easily removed when a boulder was taken out, which could not be done with the permanent frames.

The downward movement of the caisson was usually so impulsive that the blocks under the posts were allowed to crush and were subsequently dug out. In fact, their crushing was the only indication we had that any portion of the caisson was bearing particulary hard. The noise made by splitting of blocks and posts was rather ominous, and inclined to make the reflecting mind nervous in view of the impending mass of 30,000

tons overhead. No satisfactory estimate could be made of side friction. There must have been some, but of a very irregular character. At times an outside boulder would apparently hold one end of the caisson until a bolt-head or part of the timber gave way. The batter on the outside being 1 ft. in 10 ft., was calculated to relieve the caisson from side friction. The workmen, however, never dug out far enough behind the shoe, thus causing great friction for several feet up the sides, and pressing in the sides to as much as 9 in. in some places. The side friction probably never exceeded 3,000 tons. The larger the base of a caisson the smaller is the percentage of side friction available to counteract downward pressure, whereas, in a narrow caisson penetrating an uniform sand, it is often sufficient to counterbalance the whole weight.

A CURIOUS INCIDENT.

A few words will suffice to explain the mode of operating the supply shaft. It consists of a tube 45 ft. long and 21 in. diameter inside, with a door at the bottom opening into the air chamber, and a long door on the top, through which the material is thrown in. When the upper door is open, the lower one is held shut by the air pressure, assisted by 2 iron clamps worked by levers. As soon as a certain quantity of material has been thrown in, the upper door is pulled up, and the compressed air being thus allowed to enter, firmly closes it. When the shaft is filled with compressed air, a signal is given to the attendant below, who removes the lugs, the door falls, and the contents of the shaft drop into the air chamber. The operation is very simple and rapid, and perfectly safe with the most ordinary precaution. Two of these shafts were found ample to furnish all the material required for filling up the caisson. They had worked well for 5 weeks, but danger always steps in when, through use and familiarity, the attendants become careless and reckless. It had occurred at times that a charge of building stones or brick would become jammed, and only part of a load would drop out. To ascertain this fact a string with a weight was let down from above each time, so as to avoid putting in a double charge. Upon this occasion a charge had jammed, the men dumped in another, without measuring the depth either before or after, and then gave the signal to the man below, without shutting the upper door, or letting in the compressed air. The second charge happened to loosen the first, and the two together overcame the pressure against the lower door, when the lugs were turned. As soon as this happened, the air commenced to rush out of the caisson with a great noise, carrying up stone and gravel with it. The men above ran away, leaving those below to their fate. Any one with the least presence of mind could have closed the upper door by simply pulling at the rope.

I happened to be in the caisson at the time. The noise was so deafening that no other noise could be heard. The setting free of watery vapor from the rarefying air produced a dark, impenetrable cloud of mist, and extinguished the lights. No man knew where he was going, all ran against pillars or posts, or fell over each other in the darkness. The water rose to our knees, and we supposed, of course, that the river had broken in. It was afterwards ascertained that this was due to the sudden discharge of the columns of water contained in the water shafts. I was in a remote part of the caisson at the time; half a minute elapsed before I realized what was occurring, and had groped my way to the supply shaft, where the air was blowing out. Here I joined several firemen in scraping away the heaps of gravel and large stones lying under the shaft, which prevented the lower door from being closed. The size of this heap proved the fact of the double charge. From two to three minutes elapsed before we succeeded in closing the lower doors. Of course, everything was all over then, and the pressure, which had run down from 17 to 4 lbs., was fully restored in the course of 15 min. A clear and pure atmosphere accompanied it. The effect upon the human system and the ears was slight, no more than is experienced in passing out of the airlock.

Under the head of "Fires," Mr. Roebling details the history of the fire of December 2.

LIGHTING OF CAISSON.

The subject of illuminating a caisson in a satisfactory manner, is rather a difficult

problem to solve. A powerful light is of prime necessity, to overcome the want of all reflecting surfaces, to penetrate the thick mists usually occupying such places, and to illuminate every foot of a soil which was anything but uniform in character. The burning of candles is attended with an intolerable amount of smoke, resulting from a rapid but incomplete combustion. This nuisance was overcome somewhat by reducing the size of the wick and of the candle, and by mixing alum with the tallow, and also steeping the wick in vinegar. The inhaling of so much floating carbon is very injurious to the lungs, as the lampblack remains in there for weeks and months. Nevertheless candles have to be used more or less for all special work requiring illumination close by. Lamps are of little account, since they smoke more than candles, and the oil is dangerous in case of fire.

Fortunately, the existence of an establishment in New York for the production of oxygen gas in large quantities and at moderate prices, made the introduction of calcium lights quite feasible.

ORGANIZATION OF WORKING FORCE.

Each shift of men worked in the caisson 8 hours at a time, the first watch from 6 A. M. to 3 P. M., including one hour for breakfast; the next watch from 3 P. M. to 11 P. M., including one hour for supper; then a special night gang from 11 P. M. to 6 A. M.

The majority of the men took their meals along and remained down the full 8 hours without any injury.

The 2 day shifts alternated from week to week. They consisted of 1 general foreman, 6 assistant foremen (1 for each chamber), and 112 laborers. The special night gang was composed of 1 general foreman, with 2 assistants and 40 laborers, making a total force below of 3 general foremen, 14 assistants, and 264 laborers. This force was constantly recruited from time to time, and an inspection of the time-books shows that 2,500 different men have worked in the caisson.

On deck there were double shifts of engineers and firemen to run the excavating engines, and engines for running the dirt cars, also 2 gangs for attending to the dumping of the latter. In addition there were the engineers for the air compressors, and stone hoist engine, blacksmiths, machinists, and gas men, one gang to remove the boulders brought up by the buckets, a carpenter's force of 25 men, and 30 men for setting masonry. The total daily force amounted in all to 360 men.

DOCK.

During the winter months the substantial dock resting on top of the caisson, on the river side, was completed, filled in, and provided with a track, turn-tables, and unloading derrick.

NEW YORK CAISSON.

The plans for this caisson were perfected in the summer of 1870. A contract for its construction was made in October, with Messrs. Webb and Bell, the builders of the first caisson, the iron work being done by John Roach & Sons, of the Morgan Iron Works. It was built at the foot of Sixth street, New York, the old yard in Greenpoint having been abandoned for shipbuilding purposes.

A rather severe winter, with delays on part of the iron work, prolonged the completion of it to the 8th of May, on which day it was launched with the same success attending the first launch. It is now lying in the Atlantic Basin, where 7 additional courses of timber and concrete are being put on preparatory to its removal to its permanent site. In its construction this caisson is in its general features a duplicate of the Brooklyn caisson. It is built of yellow pine timber, the air chamber being lined with a thin skin of boiler plate on the inside. The roof consists of 5 courses of yellow pine sticks, 12 in. square; the inclined sides surrounding the air chamber are also of yellow pine, and are 9½ ft. high on top, and taper to a rounded cutting edge of cast-iron, 8 in. wide, and enveloped by an armor of boiler plate.

The timbers in all the courses are scarfed and bolted together with screw bolts and drift bolts. About 180 tons of bolts were used in the fastenings. The dimensions of the base are 172 by 162 ft., covering an area of 17,544 sq. ft. Its length is 4 ft. greater than the Brooklyn caisson.

The air chamber has a height of 9 ft. 6 in., and is divided into 6 rooms by 5 main frames. The rooms vary from 25 to 30 ft. in width, by 102 ft. long, and are

subdivided by lighter secondary frames running through the middle. In addition there are two heavy cross frames extending through the whole length of the caisson. The amount of bearing surface is 18 per cent. of the whole base, and will be increased to 25 per cent. of the whole base by reason of the sloping sides, in case the caisson should sink into the soil 2 ft.

The main frames are of solid timber, and 4 ft. wide, composed of two central ties of horizontal timber and two outer rows of posts. They are secured to the roof by long through bolts, extending through the lower three courses of the roof and are heavily braced sideways. The ends of the frames are secured to the sides of the air chamber by knees and iron straps. Each frame is pierced by doorways of ample size to afford communication between the adjoining chambers.

The secondary frames are open work, composed of posts and sills, and can be strengthened if the necessity should arise. An iron skin lines the inside of the air chamber. The iron is light boiler plate, of No. 6 gauge. A light iron was purposely selected in order to overcome to some extent by its buckling, the difficulty arising from the expansion and contraction of so large a surface rigidly bolted to an unyielded mass of timber. In addition, a series of expansion joints of angle iron were put in transversely to aid in taking up the contraction. No trouble has been experienced from this source since the launch. All spaces between the skin and the timber have been filled with cement.

FLOOR.

The New York caisson was launched with a temporary floor extending over the whole base. This was made necessary by reason of the shallow water in front of the launching ways. The floor will remain until the caisson is permanently grounded on the river bed, and will help materially in maintaining a level position of the same.

The air chamber will not be inflated until the caisson has touched bottom, and enough masonry has been laid to prevent its rising at high tide and from the pressure of the compressed air. This floor then comes into play to distribute uneven pressures until access is had to the air chamber and the work of excavating has commenced.

TABLE OF QUANTITIES. NEW YORK CAISSON.

Length over all	102 ft.
Breadth	102 ft.
Height	14 ft. 6 in.
Area of base	17,554 sq. ft.
Quantity of timber	118,00 cub. ft.
Weight of bolts	180 tons
Weight of ironwork	200 tons
Launching weight of caisson	3,250 tons

SHIFTING STUFF.

From "The Building News."

In all contracts, whether they relate to the erection of a Crystal Palace, the construction of a railway, or the cutting of a Suez Canal, there is invariably a particular kind of work, a certain portion of the estimate, that pays better than any other. This is by no means in proportion to the quality of the work, or its price, although it unquestionably depends, generally speaking, upon the quantity. Occasionally, items of small amount, for which a large price is allowed, are a good thing for the contractor; but, as a rule, the items heavy in quantity and small in price per unit of measurement, pay the best. A genuine contractor likes a "big job." He likes to deal in generalities. Petty, insignificant contracts allow no scope for the exercise of those peculiar talents which have always distinguished the English contractor. On the other hand, a large contract affords facilities for, and in fact demands, all the energy that he possesses; the readiness, aptitude for contrivances and make-shifts, promptitude in seizing every occasion that presents itself and turning it to account, indefatigable attention and untiring perseverance that all our great contractors are endowed with, are then capable of being displayed to the best advantage. It must not be supposed that those gentlemen pay no attention to, or have no knowledge of, details of works. The truth is that the reverse is the case. The most intimate knowledge of the

value of details, and a close study of their immense importance and bearing upon work, is indispensable to every one who intends to make money by contracting. But this acquaintance with the minutiæ of work does not prevent the contractor preferring to deal with them *en masse*. In order to traffic in tons and parts of tons, one ought to be acquainted with the price of the article per cwt. or per lb., as the case may be; but one is not in consequence limited to trading in the smaller amounts. There is just the same difference between one of our merchant princes and a small retail tradesman, as there is between a Brassey and a local builder and contractor. So well is this difference recognized and established among the parties themselves, that a contractor of the former calibre would no more think of tendering for certain descriptions of contracts than a wholesale city merchant would consent to supply private families with goods.

The days most fortunate for contractors were those which witnessed the infancy of railways, and it is incontestable that the most paying parts of the contracts was the earthwork. In other words, the amount of stuff to be shifted was the pith and marrow of the contract. This was always the heaviest item in the construction of the early lines of steam communication. Attempts were then made by engineers to approximate to the *beau ideal* of a railroad—namely, that which should have no curves and no gradients. No wonder there was an immense quantity of stuff to be shifted; no wonder that the earthworks were heavy when a curve having a radius of 1 mile was considered sharp, and a gradient of 1 in 100 was regarded as almost too steep for the powers of a locomotive. If we draw the proper distinction between rural and urban railways, it will be admitted that in the construction of the former, especially of the earlier examples, heavy cuttings necessitated correspondingly heavy embankments. The engineer, in order to avoid the "running to spoil" of any of the earthwork, endeavored to adhere to the golden rule so familiar at that time to young members of the profession: "Always make your cuttings equalize your embankments." At the present time this rule, though correct in the main, is not so strictly adhered to as formerly, nor could it be, bearing in mind that our system of railway construction has undergone great modification since the days of the fathers of steam locomotion. Embankments are easy enough to construct when there is plenty of stuff to be got for the purpose from the nearest cuttings, or even when, at the worst, they can be made up from side cuttings. But the case becomes very much altered when an embankment is necessary and no stuff can be got in the neighborhood to make it with. Abundance of examples of this are to be seen in the vicinity of London, where earthworks are replaced by viaducts of brickwork. Instances have occurred in the construction of railways in which a viaduct has been built in the place of an embankment, not because stuff could not be obtained along the line for a solid bank, but because the cutting from which the supply would have to be drawn was at too great a distance, that is, the "lead" was too long. It was cheaper to use a more expensive material than to run the other so far. It is in balancing up these several discrepancies, and forming a correct judgment of the method to employ, that the genius of the contractor is displayed. It must be borne in mind that "shifting stuff" in the open country, and in a city similar to London, are totally different matters, and that our remarks apply, to their full extent, only to the former description of work.

Assuming that our statement respecting the comparative advantage and pecuniary benefit to the contractor of a large amount of earthwork in a contract is accurate, the question will naturally be asked—why? A little consideration will demonstrate the reason, and in order to render the subject clearer, let us compare earthwork with brickwork. In the first place it is a great deal more difficult, particularly for an engineer, to estimate what the cost of shifting so much stuff in certain situations will come to, than it is for him to arrive at the cost of so much brickwork. The price of bricks per thousand can be ascertained to the fraction of a shilling; the cost of the labor to build a rod of ordinary brickwork can also be known to the same degree of accuracy; and, moreover, there is only one way of going to work about it, in whatever locality the operations may be car-

ried on. But it is far otherwise with earthwork. Independently of the fact that the price varies very widely with the nature and situation of the material, there are numerous ways in which the shifting may be accomplished. It may be run in barrows, carted away, removed in barges, as occurred during the construction of the Thames Embankment and the Metropolitan District Railway, or conveyed away upon a tramway, either by horse or steam power. The difficulty of arriving at a correct estimate of the cost of shifting stuff was well exemplified in the early days of railways on the Continent. The French engineers made their usual mathematical and elaborate calculations respecting the effect that the different "leads" would have upon the price, and their own native contractors followed suit. As may be imagined, the French tenders were enormously high. Without in the least troubling themselves about calculations of any but a very simple arithmetical character, the English contractors made their estimates, which were much lower than those of their foreign *confrères*, and obtained the contracts. It is not too much to assert that to this circumstance of readily and correctly estimating what the cost of shifting stuff would be is due the great amount of foreign work executed by English contractors. It enabled them to get a footing in foreign countries which they have never lost. Another reason why earthwork is usually so paying a job for the contractor is, that he is at liberty to use any method he pleases of executing it, which is not the case with other descriptions of work. He is not hampered by a variety of conditions which are attached to other items. After some practice and experience, it is not surprising that the contractor becomes endowed with a special faculty of devising means to execute earthwork cheaply and effectually. That this is the case is amply manifested by the circumstance that some contractors tender for earthwork, if not altogether, at least in preference to other descriptions of work. Again, on a large job, it is a common occurrence to let out the shifting of stuff to sub-contractors, who not only make a profit out of it themselves, but leave a balance also to their employers. There is, perhaps, one exception to the opinions we have expressed—that is, where the shifting of stuff takes the shape of water work. But, at the same time, a high price is always allowed for such work, as there are so many contingencies to be provided for. It must, however, be confessed that there is always some risk incurred in all works in which water is present; and here, as in many similar instances, the contractor must put a little faith in his good luck.

BOILER EXPLOSIONS.

From "Engineering."

The labors of the second Committee upon Boiler Explosions have come to an end, and its report has been submitted. It will be remembered that a select committee was appointed last year, and that in June and July it held many sittings, received much evidence, and finally recommended that another committee should be appointed at the ensuing session to conclude the work of investigating the subject. On the 25th of April last, this second body finished its work, and on the 20th of June sent in the report. One of the conclusions arrived at is, that a general system of boiler inspection cannot be insured without making that inspection compulsory, and the committee is not prepared to recommend for adoption any system of this nature.

This conclusion is arrived at partly because it is believed a large number of explosions occur annually from causes that are and would continue to be independent of anything that could be prevented by periodical inspection, and partly because it is considered doubtful whether compulsory inspection would not lessen the responsibilities of owners, and tend to make them careless as to the class of men they employ.

The most important recommendation contained in the report is, "that it be distinctly laid down by statute, that the steam user is responsible for the efficiency

of his boilers and machinery, and for employing competent men to work them, and that in the event of an explosion, the onus of proof of efficiency should rest on the steam user." It is also recommended that, as an average coroner's jury cannot satisfactorily investigate the causes of an explosion without the aid of competent professional advice, that whenever an explosion occurs, the user shall report the same to the district coroner, who shall communicate with the Board of Trade, which shall instruct one of their competent surveyors to attend the coroner and assist him in his investigation.

Among the resolutions proposed were those having reference to the inspection of new boilers, as follows:

"That it is desirable that a preliminary inspection of boilers should take place, so as to secure:

"(*a*) That the boiler is capable of bearing a working pressure equal to that at which it is intended to be worked.

"(*b*) That it has all necessary fittings to prevent the steam ever attaining a greater pressure than that prescribed, and to secure a proper supply of water to the boiler.

"(*c*) That the boiler is so fixed as to afford ready means for external examination.

"That an inscription should be put up on a conspicuous part of every boiler to the effect that, when new or last examined, it was testified to be fit to work up to a certain pressure, to be therein stated."

Besides this the resolution refers to the provision of sufficient penalties for those owners who are guilty of negligence, or for those who work a boiler without a certificate.

In declining to recommend to the Government any scheme for the compulsory inspection of boilers, the committee has doubtless been influenced by the evidence and opinions of the large number of witnesses examined, and the majority of whom, whilst advocating strongly general inspection, deprecated Government interference, and proposed plans, most of them more or less practical, but none of which would meet all the requirements of the case.

The experience of the leading Boiler Inspection Associations militates against the conclusion of the committee, that a large number of explosions occur from causes unpreventable by inspection. The statistics of boiler explosions show that those users who encourage periodical inspection, rarely, very rarely suffer, whilst the bulk of accidents happen to uninspected boilers. It is true that this almost total immunity from accident, on the part of the former class, cannot be ascribed entirely to inspection, for those users who adopt this precaution naturally observe all the other conditions of safety, and are, in fact, the careful class of steam users, as opposed to the other and larger class of careless owners.

The committee, however, endeavors to get over this difficulty of compulsory inspection by throwing the entire responsibility upon the steam user, and recommending that he should be made responsible not only for himself, but for his servants, the onus of proof of efficiency both of boiler and workman resting upon him. This we consider in itself a wise conclusion; we have repeatedly in these pages called attention to the gross carelessness and the astounding ignorance that conduce so often to boiler explosions, and we have always advocated that steam users should be made responsible for any possible damage they may cause. At present it is too often the case that the unfortunate servant in charge of the boiler which explodes is saddled with all the responsibility, and takes the punishment. In some cases this is just, but in how many cases is it unjust? If the man is ignorant of his business, it is the fault of the master that he employs him. If the boiler is unreliable and unsafe, it is not the crime of the workman, who has to gain his livelihood by attending it, but that of the employer who allows it to be worked. How many men there are in the position of Lambert, who gave evidence before the committee, and who said with reference to the boiler he looked after, "I can tell you that when the engine is working at 20 lbs. I am much more happy than when she is working at 40 lbs.," and who works under the settled conviction that "he should be up in the air where the boiler is, if the boiler should burst!" These opinions may, of course, be prejudiced, and his boiler may be perfectly safe, but they are the exact opinions of a large body of working men, who are compelled to undertake risks

every hour of the day, and who have no means of helping themselves.

Doubtless a rigid observance of the committee's resolution, that responsibility should be placed upon the users, would do a great deal to ameliorate the present state of affairs; for, having the fear of consequences before them, masters would naturally practise caution, and take such steps as they deemed best suited for their protection. But in doing this they would be likely to run into other dangers. We are not speaking now of the large users of steam power—the boiler aristocracy, so to speak—but of the crowd of small owners, amongst whom the greatest danger of explosion occurs. Such a legislation as that proposed would be the signal for a large number of inspecting and insuring associations to come into existence, many of which would probably be of a class totally different to the excellent ones now at work.

These might find lucrative business, but they would prove of little service to the steam user, who, lacking either judgment or prudence, places his reliance in inspectors whose ability and probity are not proved. So, then, he would continue in false security, until an explosion, and its consequent penalties, might end in ruin.

The committee are of opinion that general inspection would be impossible without compulsion, but they appear to overlook the fact that unreliable inspectors will conduct many into the paths of penalty prepared by legislation, whilst those who take no precaution will, it is true, be punished, but not till after the mischief that ought to have been avoided, has occurred. Prevention is in all cases better than cure. Prevention can practically be achieved by proper inspection, but proper inspection cannot be universally secured unless under compulsion; therefore, compulsory inspection ought to precede the penalties which should be inflicted under all circumstances where carelessness can be traced to the user.

With regard to the efficiency of boiler tenters, employers would, if a vigorous and just legislation existed, use every precaution to obtain good men, who might be compelled to show certificates of capacity before obtaining employment. In fact, Lambert, the engine driver, in his own way, summed up the requirements very justly in our opinion: "That inspection should be compulsory, and done by the Government, and that inspectors should be appointed who should see that there were competent men employed to take charge of engines and boilers, and the same to receive a certificate that he is a competent man."

That Government inspection would be considered as oppressive by the majority of boiler users we can readily believe, but as we have before expressed our opinion, we consider that it would be the only really efficient form of inspection, if carried on under sufficiently elastic conditions. With the assistance and experience of the several able men now conducting the leading associations for the same purpose in this country, the work could be systematized and so arranged as to interfere but little with the convenience and prejudices of steam users, in fact, to a less actual degree than would the operation of a number of independent bodies; of course the sentimental grievance against Government interference would probably be of long duration.

There can can be no doubt of the value of preliminary examinations of boilers before they are put in use, the extended business of manufacturing boilers, the keen competition that exists in the trade, the desire on the part of purchasers to obtain cheap boilers, the willingness on the part of makers to accommodate their customers—all of these causes demand a thorough investigation of boilers before they leave the shop. Whether this will form a part of the new legislation on the subject remains to be seen; if it does not, there will be a serious defect in the Act; if it does, there can be no valid reason why the official inspection should not be extended further, and apply to the 100,000 boilers now under steam in this country, and the explosion of many of which is only a question of time.

The preamble of a bill for the construction of a new line of railway from Preston to Southport has been deciared proved. Mr. Brunlees, C. E., the engineer of the proposed line, stated in his evidence that the probable cost of construction would be £144,000; the works were easy, the steepest gradient being 1 in 94.

THE COINING OF GOLD.

The following interesting account of the chlorine process of coining gold, now in use at the Mint, is taken from the "Standard": —

The statements which have been of late made in Parliament and the press, respecting various matters connected with the operations of the Mint have given a public interest to the only notable improvement in the metallurgy of coining which has been made in the present century. Indeed the whole process of coining is so old, and was so far perfected at a very remote age, that after the application of machinery not very much has since remained to be done. There was, however, one trouble, causing great annoyance, which had existed from time immemorial, and which was the more vexatious that no inspection of the metal when received could effectually guard against it—brittleness. The ingot might be, to all appearance and test, as tough as it should be for the coinage, and yet when the processes of minting were far advanced, a portion of the mass might turn out of such brittleness as to necessitate its return to the importer—of late years almost solely the Bank of England —and thence again to the refinery. This difficulty has been entirely overcome, and by a process so inexpensive as to be practically costless ; and now, instead of returning the gold as heretofore, it is treated at once in the Mint itself, and the full coinage of the quantity brought in is completed, without even the importers being made aware at all of any imperfection in the condition of any of the ingots. The chlorine process by which this admirable result is effected is equally simple as inexpensive. The intractable gold is merely put into a crucible and remelted, having, while in that state, a jet of chlorine gas passed through it by the insertion of a clay pipe into the mass of liquid metal. Thus is effected a combustion of impurities, very much, as one might say for comparison, like the Bessemer steel process, only substituting chlorine gas for common air. In the Mint works a large glass jar about 15 in. or 18 in. high, containing the hydrochloric acid, is placed against the back of the wall of the furnace-house, at about 12 ft. from the ground, and a piece of glass tubing, 8 ft. long, connects it with a chlorine generator below, capable of containing about 8 gallons, and from which a $\frac{1}{4}$ in. pipe is passed through the wall, the clay nozzle of which is inserted into the crucible for about 5 min. at each operation.

In thus treating brittle gold, two grave points of consideration had to be met boldly at the outset. The brittleness in the standard gold arises from the presence, in very minute quantity, of lead, antimony, arsenic, or bismuth. This minute quantity—as little as 1.1900th part —sufficing to render the gold too brittle for coining—made it necessary, on the one hand, not to employ any process which should volatilize and waste the gold. On the other hand, the chlorides are either volatile, as in the case of those metals which occasion brittleness, and in such combinations are driven off by the heat ; or, as in the case of silver, melt into a fluid mass which floats on the surface of the gold. If, however, we compare the loss of the valuable metal in the chlorine process, as conducted at the Mint, with the loss regularly experienced in the ordinary process of gold-melting, which is 1 gr. per troy lb. of gold, we shall find that the results are highly satisfactory ; in fact, the initial loss by the chlorine process may be briefly stated as 19 parts in 100,000, whilst the experience of the melters of the Mint is, that the ordinary loss by ordinary melting amounts to 17 parts in the 100,000, of which in both cases the greater portion is recoverable. The bearing of this success in manipulation goes to show that at the extremely high temperature at which the operation is conducted, chloride of gold does not exist, being in fact decomposed, whilst the chlorine combines rapidly with the baser metals. Any very light loss of gold, therefore, that may take place, must arise either from its being mechanically carried away, or from the production of a volatile compound of gold and the volatile metal with the chlorine introduced. Of the inexpensive nature of the apparatus, and the materials employed in the chlorine toughening process—for the gold so treated comes out of the crucible perfectly workable—we

may say that the amount of chlorine required for £10,000 worth of gold would not cost 2s., and that the whole apparatus for generating it could be put up for a couple of sovereigns.

Another topic deserves public notice, namely, the perfectly innocuous character of the process. The Mint operations are at all times, on account of the rarity and value of the materials dealt with, very small in scale compared with the metallurgical processes of the great manufactories of the ordinary metal industries; and even of these, the toughening process is only applied to the smallest quantity of the most valuable metal. There is, and has been, no need for its employment for more than a total of 3 days a-year, taking in the most active seasons, and then only for a few hours at a time. Between the generator and the furnace every joint of the apparatus is made tight, and there is no escape for any of the gas, excepting up the flue—and what, indeed, if the whole went up, would that quantity, ejected from the top of a lofty stack, during 3 or four hours' work, into the full current of the winds, effect in the way of nuisance to any neighborhood? Even in a perfectly calm day, the amount of chlorine so disseminated in the atmosphere would not be enough to be smelt; and, if it were, it is by no means unwholesome, but, on the contrary, a very effectual destroyer of disease-malaria. It is a pity, therefore, that critics who are not chemists enough to understand the point in question should attempt to prejudice the Government and the public against, not only this useful operation, but also against the removal of the Mint to Whitefriars, where it would have a frontage towards the Thames Embankment, by raising phantoms of nuisances and annoyances which never did, and never can, have any reality. To discuss the question of a transference of the Mint from Tower-hill to the vicinity of the Strand is not part of our present purpose; but we may add, in passing, that a small manufactory, such as the Mint is, and ever will be, can be much better and more economically managed if compacted in one moderate-sized building than it can be in a multiplicity of buildings, spread over 5 acres, as it is at present.

Returning to our immediate subject, we may note that the gold coins of the country are not fine gold, but an alloy of copper with 916.6 parts of gold in 1,000 of the mixture. This is "standard gold." Brittleness can very seldom be detected in the ingots of pure gold as received, and the friability is often exhibited after the formation of the alloy, the quality of the copper needing careful selection. The alloy, when free from impurities, is tough and malleable, but when, as we have said, there is a small amount of some of the baser metals present, it may be as brittle as loaf sugar. Refining silver and gold, that is, removing either metal from the other, as well as from foreign or impure metals, is ordinarily a long and tedious operation. The process of refining was, however, much simplified by Mr. F. Bowyer Miller, of the Sydney Mint, who found that when chlorine gas is forced through a molten mixture of gold and silver, the latter metal is converted into chloride of silver, which rises through the gold and floats on the surface of the metal, and the separation of the gold and silver is thus easily effected, the quality of the metal proving excellent. This process has been further developed in its direct application to the toughening of standard gold by Mr. W. Chandler Roberts, the present chemist of the Mint, a pupil of the late most eminent Mr. Graham, and associated with that great chemist in his memorable researches on palladium. Mr. Roberts' able report upon this subject combined with the success realized in the practical operations, ought to insure for him a higher recognition than even that of a very useful public servant; and viewing the chlorine system in its other aspect of a refining process, it will be to his pioneering that the credit will be mainly due, should it in this country replace in a few years the existing tedious operation of refinery. Short as is the period since its adoption at the Mint, some 40,000 oz., or nearly $150,000 of brittle gold have been already so treated, and this so effectually that the severest tests have been applied to the coins with impunity. It will require, however, a study of the voluminous correspondence, printed in the appendix to the first annual report of the Deputy Master of the Mint, to understand fully the vexatious nature of the difficulties arising from this source, which are now completely remedied.

WHAT IS STEEL?*

By ANGUS MACPHERSON, C. E.

From "The Mechanics' Magazine."

It is only when we know a subject thoroughly that we can come to a positive decision upon it, and we know so little even yet of steel that we are continually changing our answers to the above question, which appears to be one of the simplest that could be asked. As a student, he would have answered readily enough: "Steel is a carburet of iron, most probably composed of 20 equivalents of iron and 1 of carbon; as the combining equivalent of carbon is 6, and that of iron 28, there are present in steel 6 atoms of carbon to every 560 atoms of iron, *i. e.*, steel is iron carburized to the extent of rather more than 1 per cent." This theory, however, has not been found to stand the test of practical experience either in the foundry or in chemical analysis, which, instead of giving the foregoing elements, shows the most variable results. Instead of returning the probable combining equivalents of iron and carbon, it steered as wildly wide of the theoretical proportion of carbon as to range from 0.25 to 1.25 per cent. This aroused the suspicion that the chemical action was more an impregnation of the iron by carbon, than an actual proportional combination—an impregnation of the iron, as it were, in a carbon bath, as in cementation, where the two elements are supposed to be chemically cemented by the operation.

Then there appeared another fact. It was found that steel could be made without carbon at all, and so could no longer properly be denominated a carburet of iron; that term must henceforth be restricted to carbon steel alone, for iron can in like manner be impregnated with silicon, titanium, chromium, cyanogen, tungsten, etc. Nay even with the supposed hurtful elements of sulphur and phosphorus, so as to have all the distinctive properties of steel, with slight variations, of course, according to the nature of the qualifying substance.

Thus far, then, the question may be answered, iron is the general and steel the specific form of the metal. Steel is merely iron steeled or hardened, by being chemically impregnated with carbon, silicon, titanium, or any of those elements which possess more or less the hardening property; chemically impregnated, as the iron does not lose its special qualities, which it would do if the two elements were proportionately and chemically combined so as to form a new compound substance. There is, of course, a definite proportion of the chemically impregnating element, which confers the greatest amount of steeling or hardening property, entitling it so far to be called pre-eminently steel-iron, or simply steel, variations from which proportion cause the metal to vary in respect of this property of hardness. According to this view we may regard ordinary cast iron as impregnated with too much, and wrought iron with too little carbon, in both cases falling short of its strongest form, steel; or cast iron is a mixture of antagonistic steel and wrought iron, which is a very mild form of steel. Thus iron, which, in its pure, simple state, is comparatively soft, is chemically toned by carbon, silicon, or any one of the other elements used in forming steel. This toning may be underdone or overdone, or the different tonics may be all mixed up together, and so modify or neutralize each other's tonic influence. The same toning or hardening influence is to be found in the vegetable world, where we find silicon toning the strength of plants, as, for instance, in the straw of cereals, which is more or less stiff and hard in proportion to the prevalence of silicious constituents in the soil on which it is grown; the length as well as the quality of the straw being influenced thereby.

The Bessemer process demonstrates distinctly the fact that there is no definite boundary between the 3 forms; that the percentage of carbon can be very gradually decreased from 1.25 per cent. to a percentage scarcely appreciable in practical analysis, without altering the essential properties of the steel, except in lessening the degree of hardness. As the greater the percentage of carbon, up to a certain point, the harder is the metal, so the

* From a paper read before the London Association of Foremen Engineers.

substitution of a harder impregnating element may be expected to produce a still stronger quality of steel, as, *e. g.*, with silicon; or the substitution of a softer impregnating element may be expected to produce a weaker quality, as with phosphorus, and this really seems to be the case. Carbon steel, however, is the kind in general use, and the only one whose qualities have been subjected to practical investigation. I shall, therefore, restrict my remarks to it. It is not only the proportionate amount of the carbon with which it may be impregnated that determines the hardness of the steel; for the same metal can be tempered, or have its hardness moderated.

Crystallization plays a necessary part in imparting the steeling or hardening property. This is obvious in the practice of hardening steel by plunging it suddenly into cold water, by which it can be rendered so hard as to be capable of scratching glass. So also, on the other hand, an extreme degree of hardness may be reduced to almost any degree of softness by heating the steel. All the gradations are beautifully marked on the bright steel in deepening rainbow tints, guiding the manipulator by visible signs as to the relaxing temper of the metal.

The first tinge of yellow indicates that the steel has barely begun to soften, though it has materially increased in toughness. As the yellow deepens towards orange, the color indicates the degree of temper required for such articles as razors, penknives, and tools for turning, planing, chipping, and boring.

As the orange deepens, the color indicates a temper suitable for joiners' edge-tools and table-cutlery. When the changing color runs into blue a temper is indicated that fits the metal for springs, and when it has completed the revolution and arrived at the color from which it started the metal has become nearly as soft as before it was hardened.

It is pretty evident the relaxing temper of the metal is associated with a chemical action of the heat on the crystalline molecules of the iron. This action is, as yet, not very well understood. It depends not only on the nature of the crystallization of the iron, but probably also on the determination of the axial direction in which the crystals are formed. Only the finest iron is used in making good steel, and the purer the iron the larger the crystals, but the quality of the steel depends also greatly on the amount of carbon, and the chemical admixture of a foreign element reduces the size of the crystals.

The finer the steel the closer will be the grain of the fracture. This brings us to another phase of the question, What is steel? It may come before us in another form. How can steel be identified? How can its varying qualities be distinguished? This is the practical bearing of the question for those who have to realize it by inspection, and on correctness depend very important consequences. Supposing a piece of steel to be submitted for inspection, how can we test its character? If it be a steel rail, it ought to contain $\frac{1}{2}$ per cent. of carbon. If it be a mild steel casting, it ought to contain about $\frac{3}{4}$ per cent., and if it be a piece of hard cutlery, about $\frac{1}{4}$ to $\frac{1}{2}$ per cent.

Of course the most correct estimate would be formed by analyzing the steel chemically, but that cannot be resorted to in the rapid turn-out of a factory, to any great extent. The nearest practical approximation to this is to dissolve a small piece of the steel in an acid, when the differing shades of brown will indicate the inherent proportions of carbon. Steel may also be tested as to its proportionate quantity of carbon by ascertaining its specific gravity, as the greater the proportion of carbon the less dense will it be found to be. The readiest method of testing the quality of steel is by examination of the fracture in a microscope. This requires considerable experience and a very powerful instrument. The unassisted eye may make a tolerable guess, but the result cannot be relied upon. Not so, however, where its power is multiplied by the powerful lens of a microscope. The crystals are found then to be octohedral, presenting the form of a double pyramid, joined base to base. As the carbon decreases, the pyramids become flatter, from the cubical form in cast iron down to the flattened form in wrought iron, which confers upon it greater capacity of being welded, and thus producing fibre. Between these extremes may be found a graduated series of pyramidal forms more or less elevated, according to the quality of the metal. If

the steel shows under the microscope a regular and parallel crystallization (which may be pretty accurately ascertained if the fractured metal be held against the light), flashing back to the eye an uniform lustre, like evenly serried needle points, the steel is of good quality. In proportion as it departs from this standard and shows groups of crystals whose discal directions are not parallel, causing the needle-like fragments of crystals to reflect a lustre patched here and there with shade, imparting to one portion a bright silvery tone, and to another a dark gray one, the metal is of inferior quality or make. Fineness and parallelism of grain can be produced by repeated melting, heating, or hammering, when cold or at a dull red heat. Cold hammering has the effect of producing an extremely fine grain.

A more correct estimate of what steel really is has had the effect of materially shortening the process of manufacture. The material itself has been made for upwards of 2,000 years, but only now, in the latter part of this wonderful century, has its manufacture been developed so as to show its capabilities. Only the practical appliances of these modern times could master the conditions necessary to simplify its manufacture. No process can be more direct than that of Bessemer; its only drawback is the very limited quality, and therefore quantity, from which proper material can be drawn. The great mass of our pig iron, in its present impure condition, is totally unfit for the Bessemer process. The pig iron must not contain less than 1 per cent., nor more than 2 per cent. of silicon. The percentage of carbon may be as high as possible, but must not be less than 3 per cent., and it makes no difference whether it be combined or uncombined. The percentage of manganese should not be more than 3 per cent., because, having a greater affinity for oxygen, a very violent action ensues in the converter, when the percentage is higher, causing explosions, and ejecting the metal. Silicon counteracts this, so that if the percentage of silicon be in excess, each unit of percentage will work quietly with 2 per cent. extra of manganese. Sulphur, phosphorus, and copper are limited to 0.05 per cent. at the most—of all these phosphorus forms the most formidable excluder. The average percentage of phosphorus in Weardale iron is 1.10; in the iron of the Forest of Dean, 0.137; of South Staffordshire, 0.41; of South Wales, 0.49; Bowling, 0.51; Derbyshire, 1.0; North Staffordshire, about 1; and Cleveland, about 1.25. This limits the selection of pig iron for the Bessemer process to about 1,000,000 out of the 8,250,000 tons of iron that Europe is estimated to produce annually. About $\frac{1}{8}$th part of the pig iron produced in this country is suitable for the Bessemer process.

The next great stride in the direction of improvement seems to be the purification of the iron. Several projects for accomplishing this are competing for public favor, but as yet none can be said to have succeeded.

The importance of the question—what steel is—cannot be fully realized without some statement of the enormous advantages to be derived from its use. Its superior qualifications have never been more practically and thoroughly set forth than in the following quotation:

"Vessels of a large size, constructed to class A 1, 12 years at Lloyd's, weigh, when built of iron, about 12 cwt. per ton measurement, whereas similar vessels, built of steel, weigh only 7 cwt. per ton of measurement. Thus an iron ship to take 1st class at Lloyd's for 1,000 tons measurement would weigh 250 tons more than a steel one of the same class."

A steel vessel, therefore, would take 250 tons, or 25 per cent. more freight at the same cost, or could avail herself of the difference of immersion to leave or enter port when the tide would not permit an iron vessel to do so. As a steamer she would carry 250 tons more of coal, and thus be enabled to lengthen her voyage, or take her coals for the return trip, or a part of her superior capacity could be devoted to increased weight and power of engines, and consequent increase in speed. In fact, just as wrought has superseded cast iron, wherever toughness and strength have been specially required, so cast steel is fast superseding wrought iron, and the measure of its use is only limited by the peculiarities of the process required to be used. The peculiar toughness of steel, and its strength and power of resisting wear and abrasion, in the form of steel rails, has developed a power of endurance as much as 20 to 1 in excess of that of

wrought iron. These qualities fit it peculiarly for crossing rails. The tensile strength of steel from which these are made is about 32 tons per sq. in., being as hard as the best chilled iron, besides not being liable to chip. Of course the tensile strength itself varies according to the hardness or softness of the metal. With the increase of the percentage of carbon it becomes stronger, until with a combination of about 1¼ per cent. it is capable of resisting a strain of about 69 tons per sq. in. Beyond this, however, the metal becomes gradually weaker until it attains the nature of cast iron, which in its weakest and softest form has a tensile strain as low as 6 or 6½ tons per sq. in.

The inestimable advantages of steel being thus obvious, there is no wonder that the demand for it is increasing. Great advance has been made in its manufacture within the past few years, since Mushet and Bessemer introduced their processes. Upwards of 6,000 tons of steel can be produced weekly in England alone, which is more than 15 times the entire production of cast steel in Britain before the introduction of the Bessemer process, which has also cheapened cast steel by at least £20 per ton, thereby involving a saving of £6,240,000 per annum. There are favorable indications of a practically unlimited manufacture of the metal by a simplified process which will render it cheaper still, so that the time is not very far distant when the steel-iron bone and sinew of the moving powers of the world will be so tough and strong that they will be found never to fail under the ordinary condition of things.

CURVES UPON RAILWAYS.

From "The American Railway Times."

The resistance offered by curves to the motion of a railway train depends upon the length of the radius, the gauge of the road, the elevation of the outer rail, the form of the rolling surface of the wheels, the arrangement of the mechanism of the cars and engine, and upon the speed and length of the train. To obtain some guide for comparing lines with different systems of curves, or to be able to equate for curvature, we require to know as near as may be the general effect of curves upon the resistance to motion. The facts observed are quite discordant, owing to the great variety in the condition under which experiments were made.

In equating for grades we find first the ascent consuming an amount of power sufficient to haul a train 1 mile upon a level, or the grade of double resistance. So, too, in equating for curves we require the amount of curvature necessary to consume an amount of power sufficient to haul a train 1 mile upon a straight line. It is generally assumed that the resistance from curvature is inversely as the radius; that is, that we meet with the same resistance from curvature in running 1 mile of 2 deg. curve that we do in running 2 miles of 1 deg. curve. The number of degrees of curvature is the same in both cases. The total resistance depends upon the whole number of degrees traversed, and is independent of the radius or the length of the curve. This, however, is the mere theoretical aspect of the question. As a matter of practice, we are much more concerned with the momentary resistance than with the total resistance. We may distribute 1,000 deg. of curvature in such a manner over 100 miles of road that it shall be practically inappreciable; while, if the same total amount of deflection was put into a number of sharp reversed curves, they might affect the capacity of the road to a very material extent. In equating for curvature, therefore, as in the case of grades, any rule for proceeding must be employed under the guidance of experience and common sense.

The average of numerous experiments would seem to show that the resistance upon a 10 deg. curve, or a curve of 574 ft. radius, at a speed of 20 miles an hour, is double that upon a straight line. In traversing, therefore, a 10 deg. curve a mile long we should consume an amount of power sufficient to haul a train 2 miles on a straight line. The length of a whole circle of 10 deg. curve is $574 \times 2 \times 3.1416$, or 3,606 ft.; and this contains 360 deg. The proportionate number of deg. in a mile, or 5,280 ft., is 527, which is thus the number of deg., whatever the radius, consuming an amount of power

which would haul a train 1 mile on a straight and level road at 20 miles an hour; and this is therefore the equating number for curvature, just as 24 ft. is the equating number for the comparison of grades at the same speed. But, as in the case of grades, a double expenditure of power does not involve a double cost of transportation. We, however, increase the cost of operation more in doubling the resistance by curvature than we do in doubling it by grades; since the effect of curvature upon the wear and tear of engines, cars, and track, is greater than that of grades. Taking the operation of the 1,500 miles of railway in Massachusetts as a basis, and adding for a double expenditure of power required by curves 25 per cent. to the cost of repairs of the roadway, engines and cars, and 100 per cent. to the cost of fuel, we shall increase the whole expense of operating and maintaining the roads by about 25 per cent. If, therefore, a mile of road containing 527 deg. of curvature demands the exertion of double the power required upon an equal length of straight line, and if the exertion of a double power involves 25 per cent. more expense, the number of deg. consuming an amounts of *money* sufficient to operate and maintain 1 mile of road will be 4 times 527, or 2,108 deg.; which is thus the equating number for curvature at a speed of 20 miles an hour. This number, however, being based upon a double resistance, will vary according to the actual resistance upon a straight line'; and thus according to the speed, as shown in the following table, in which column 3 gives the radius of the curve upon which the resistance is double that upon a straight line; column 4, the corresponding number of deg. of deflecting in a mile; and column 5, the equating number in degrees.

Speed in miles per hour.	Resistance in lbs. pr. ton.	Rad. of curve of double resistance.	Corresp'ding No. deg. per mile.	Equating No. in degrees.
15	9.3	636	476	1,904
20	10.3	574	527	2,108
25	11.6	510	593	2,372
30	13.3	444	681	2,724
40	17.3	342	884	3,536
50	22.6	261	1,159	4,636

The radii in column 3 are made inversely to the resistances in column 2, and the number of deg. in column 4 are found by the proportion—Length of circle (col. 2) : one mile : : 360 deg : No. column 4. The final numbers are 4 times those in column 4.

Thus, if we have two lines one 100 miles long with 4,216 deg. of curvature, and the other 98 miles long with 8,432 deg. of curvature, the equated distances would be :—

$$100 + \frac{4216}{2108} = 102$$

$$98 + \frac{8432}{2108} = 102$$

If we assume the cost of operation to be as the equated length, we may compare different routes by adding in each case the cost of construction to the operating expense of the equated length capitalized.

In arranging the grades upon any route, we may often so oppose the lightest ascent to the heaviest traffic that the resistance shall be the same in both directions; but a curve does not admit of being adjusted to a traffic preponderating in one direction; since the resistance is the same in whichever way we traverse it. We may in some cases combine the sharper curve with the easier grades, and the larger curves with the steeper grades, so as to establish a somewhat uniform maximum or ruling resistance upon the road; but generally the same natural features that demand steep grades require at the same place sharp curves.

If we would make the resistance upon any system of grades and curves uniform, where a curve occurs upon a grade we should flatten the latter to an amount sufficient to compensate for the resistance caused by the curve. We have assumed a 10 deg. curve to cause a resistance equal to that caused by a grade of 24 ft. per mile; in which case 2.4 ft. per mile per degree of curvature would be the flattening upon the grade that the resistance may be uniform.

The following table shows the amount of flattening required upon grades for curves of different radii, the speed being 20 miles an hour, R being the radius of the curve in feet, and F the flattening of the grade in feet per mile.

R.	F.	R.	F.	R.	F.
5,730	2.4	819	16.8	442	31 2
2,865	4.8	717	19 2	410	33 6
1,910	7.2	637	21.6	383	36.0
1,433	9 6	574	24.0	359	38.4
1,146	12.0	522	26.4	338	40.8
955	14.4	478	28.8	320	43.0

At different speeds, the numbers would of course vary, as the resistance depends upon the velocity; thus the following cannot be adapted to all classes of trains upon a road, but it should be made as nearly as possible to suit the average requirement. Upon the Pennsylvania Railroad the grade was reduced at the rate of 1½ ft. per mile per degree of curvature, or 9 ft. for a 6 deg. curve. Upon Mr. Ellet's Mountain Top Track in Virginia, it was found that with a 6-wheeled connected tank engine, weighing 50,000 lbs., a difference of 58 ft. per mile between the grade adopted on a straight line and that used on curves of 300 ft. radius, was not sufficient to compensate for the increased resistance due to curvature. The result, however, with an engine better adapted to curvature would be different. The immense 40 ton 8-wheeled connected engines upon the Lehigh Valley road, with the Bissell truck, traverse sharp curves with great ease. Upon the Central Pacific Railway the grades have been reduced from 2 to 2½ ft. per mile per degree of curvature on curves of from 2 deg. to 9 deg. of deflection. On the Baltimore and Ohio Railway the 116 ft. grade was reduced to 110 feet upon curves of 600 ft. radius, and is increased to 121 ft. upon curves of 1,000 ft. radius.

From what has been said, it may be seen how inportant it is to guard against the introduction of grades and curves without carefully considering their cost.

When the Pennsylvania road was built a mile of distance saved was reckoned worth $53,000; or $10 a foot. If a road costs $40,000 a mile, and the cost of maintenance and operation is $10,000 a mile, we might pay $206,666 to shorten the line 1 mile; or according to Mr. Haupt's method, if the expenses which increase with the length of the road amount to $1 per train mile, with 10,000 trains per annum we should have a capital of $166,666; with 20,000 trains a year, a capital employed of $333,333, and so on; showing a very rapid increase in the amount to be spent in shortening a line as the amount of work to be done increases. In estimating the amount to be spent in reducing grades or curves, we are of course to regard the effect of these elements upon the cost of operation in the same manner as above stated in the case of simple distance; but the interest upon the cost of *construction*, which applies to *distance*, does not apply to grades or curves. Thus, while 162 ft. of ascent, or 2,108 deg. of curvature, might be regarded as equivalent to a mile of distance in the matter of operation, they are less objectionable by the amount of interest upon the cost of building a mile of road.

It may not, though, be advisable, in most cases certainly *is not* advisable, to make so great an outlay at the commencement of construction as the above figures would indicate. After a road has been brought into good condition, when the traffic has become well established, and attention is given to obtaining the greatest economy of operation, the minor faults of location which, with a new and rough road and an undeveloped business, were not appreciated, make themselves felt, and thus point out the way for bringing the line into a state of greater efficiency.

A PROSPECTUS has been issued of the British and Foreign Tramways Company (Limited), with a capital of £500,000, in shares of £10, of which £300,000 is to be first subscribed. The Company has been formed by the parties who have been principally instrumental in the introduction of tramways into this country and the chief cities on the Continent, and they propose to devote their experience to the acquisition of such concessions as may seem to present the essential conditions of success. Arrangements have already been made for taking the Brussels and Madrid lines, of which the former has been 2 years in operation, and the latter is on the eve of completion.

UTAH SOUTHERN RAILROAD.—The laying of the rails of the Utah Southern Railroad has been commenced. Brigham Young drove the first spike, in the presence of a large concourse of spectators.

TURBINE FLUID-METER.

From "The Mechanics' Magazine."

Fig. 2.

Fig. 1.

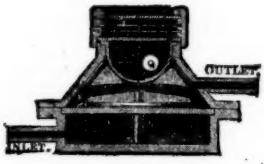
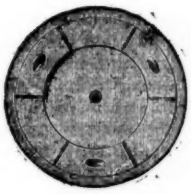


Fig. 3.



In the course of our duties as professional journalists, it has fallen to our lot to examine a considerable number and variety of fluid-meters. None of those, however, that we have hitherto seen, equal in simplicity of construction, and consequently in directness of action, that shown in the accompanying engraving, which is the patented invention of Messrs. Cook & Watson.

In our illustration, Fig. 1 is a section of the meter, Fig. 2 being a plan of the turbine disc, and Fig. 3 a plan of the plate which covers the lower compartment of the meter. From the sectional view it will be seen that this meter consists essentially of 4 parts. These are—the lower compartment, the turbine or moving part, the body, and the registering apparatus. The inlet opens into the lower compartment, which is fitted with a dished strainer, through which the water flows upwards, by the 3 oval and oblique holes in the covering-plate (Fig. 3). After passing through these holes, the water strikes against the turbine disc, the pressure slightly raising it, and impinging against the recesses in the disc, imparts to it a rotatory motion, more or less rapid according to the velocity of the water, which leaves the meter by the outlet above and on one side of the machine. The registering mechanism consists of worm-wheel gearing, actuated from the turbine spindle, and boxed off from the body of the meter.

It will be seen that as there is only 1 movable part in this meter—the turbine plate—floating freely on the fluid, friction is reduced to a minimum. When the meter is not in use, the turbine plate rests upon the bottom plate, thus preventing the return of the fluid which has passed through it, and been registered. The meter has been well tested by Mr. Simpson, the engineer to the Chelsea waterworks, who reports that, notwithstanding variations in pressure, it registers correctly.

Messrs. Pontifex & Wood also have tried numerous experiments with this meter, with pressures varying from 8 to 80 ft. head of water. Their recorded experience is that the greatest deviation from accuracy was less than 1 per cent. The offices of the Company by whom it is being manufactured, are at 37 Cursitor street, Chancery lane, where these meters can be seen at work. There can be no question as to the mechanical simplicity and accuracy of this apparatus, which, combined with its cheapness, render it decidedly the best meter we have yet seen.

Robbin's method for the preparation of oxygen gas without the aid of heat has been modified by Böttger, and is represented as affording a pure gas as readily as hydrogen can be made from zinc and dilute sulphuric acid. He takes equal weights of peroxide of lead and binoxide of barium, in a tubulated retort or flask, provided with a safety tube and pours on weak nitric acid; the evolution of oxygen takes place regularly, and the reaction is explained as follows:—Binoxide of hydrogen is first formed, and this is at once decomposed by the peroxide of lead, and pure oxygen is liberated. The mixture of the dry lead and barium salt will keep in a well-stoppered bottle, and thus the necessary reagents for the evolution of oxygen can be always on hand.

INDIA RUBBER versus IRON TIRES.

From "The Engineer."

If the Royal Agricultural Society's judges and engineers had carried out no other experiments than those which on Saturday last they conducted to a happy termination, in the sense that the results are decisive, the Wolverhampton meeting would still have deserved to rank as one of the most interesting to agricultural engineers that has ever been held. A very few years since, Mr. Thomson, of Edinburgh, patented for the second time the application of india-rubber to the road wheels of traction engines, and he had 1 or 2 engines built under his patents by Messrs. Tennant, of Leith. After a little these engines emerged from oblivion, and various paragraphs appeared from time to time in the columns of the provincial press narrating wonders concerning them. At Oxford last year india-rubber tires were for the first time introduced to agricultural engineers generally; and although the 2 engines then exhibited and built by Messrs. Tennant did nothing in any way remarkable, they attracted a good deal of attention. Then in some mysterious way the Government took the matter up. Inquiries for india-rubber tired engines began to reach England from abroad. In short, it seemed probable that a very good trade could be done in india-rubber tired engines. It forms no part of our purpose to do more than just sketch the progress of india-rubber tires to the zenith of their fame, reached just before the opening of the Wolverhampton Show. It will suffice to say that during the 12 months which elapsed between the meeting at Oxford and that at Wolverhampton 3 eminent firms undertook the manufacture of Thomson engines. These are, Messrs. Robey, of Lincoln, Ransomes, Sims, & Head, of Ipswich, and Burrell, of Thetford; while Messrs. John Fowler & Co., of Leeds, also adopted a modification of Mr. Thomson's plans. It is to be presumed that 3 such firms would not take up an invention unless they were certain that the thing was really good; but it does not appear, strange as it may seem, that they possessed any sound data to go upon which were not supplied by Mr. Thomson himself or by his friends. It is perhaps fair to Mr. Thomson to assume that he did not lend his authority to strengthen the statements which have appeared in various journals, to the effect that india-rubber tires could traverse any land however soft, ascend any hill however steep, or haul any load however heavy. Many of the claims set up for india-rubber tires were, in our eyes, and indeed in the eyes of all competent judges, grossly extravagant; but a large substratum of assertion remained, the truth or falsehood of which could not be determined in the lack of actual experiments made by disinterested men. Meanwhile, Thomson's engines were made and bought, and it is not easy to say what dimensions the trade in these machines was likely to assume. It became, therefore, of the utmost importance to decide what the true value of india-rubber, as a material for engine tires, may be. No private firm could settle the matter satisfactorily, but one private firm, Messrs. Ransomes, Sims & Head, were determined that they would do all in their power to enable the Royal Agricultural Society to decide what position india-rubber should hold in future. The experiments made by the Society commenced at Barnhurst on the 1st of July, and concluded on Saturday, the 8th. Our special correspondent has already recounted the history of the Barnhurst trials. India-rubber failed utterly on wet, soft ground. It remained to determine how it would comport itself on the macadamized roads, and to this end Mr. Bramwell and Mr. Easton spent Saturday, from morning till evening, in carrying out a series of experiments, which, for accuracy and completeness, are without any parallel in the history of india-rubber tires. The results obtained are beyond cavil or question. They indisputably settle the relative merits of india-rubber and iron tires; and, considering the great prices of the former, and the magnitude of the interest involved, they possess special and unusual value.

In carrying out Saturday's experiments, the first thing to be done was to select a road which, while fairly representing the average inclines that may be met with by traction engines, would be sufficiently steep to afford a good test of the powers

of any engine. Such a bit of road was found between Newbridge toll-gate and Tettenhall-green. In order to make all the data accurate, Mr. Easton had this road very carefully levelled on Saturday morning. Sights were taken at every 100 yards with the following results: The road was found to rise for the first 100 yards, beginning at the toll-gate, or rather a little beyond it, at the rate of 1 in 35; in the second 100 yards it rose at the rate of 1 in 20; in the third 100 yards the rise was 1 in 18; in the fourth, 1 in 22; in the fifth, 1 in 20; in the sixth, 1 in 22. Then came 33 yards rising 1 in 28; and, finally, 100 yards rising 1 in 53. The entire length levelled was just 2,200 ft., but 1,900 ft. only presented, it will be seen, any incline worth notice. The road curves gently to the left, and is partly on an embankment, partly in deep cutting through the red sandstone. In quality it was admirable, being, indeed, unusually sound, smooth, and free from ruts, or stones put down for repairs. A high wind blew the entire day, accompanied by numerous showers of rain, which dried up almost as fast as they fell; practically, the condition of the road never altered during the day—it was dry almost throughout its entire length, but not dusty. It was admitted on all sides that it was admirably suited to the intended purpose.

We have stated that Messrs. Ransomes, Sims & Head were determined to do all they could to ascertain the value of india-rubber, and to this end they brought with them to the show a pair of smooth-faced cast-iron wheels, similar in dimensions to the india-rubber wheels fitted to the Sutherland, but weighing more. It was proposed that the Sutherland should proceed to Newbridge with a proper load, and ascend the hill on her india-rubber tires first, the load being increased until, the limit of adhesion being reached, the wheels would slip, and the engine could not proceed. The particulars being noted, the engine and train were then to descend the incline, and the rubber-tired wheels were to be changed for the cast-iron wheels; the engine was then once more to be loaded and ascend the hill, the load being increased or diminished until the limit of adhesion was again reached. It will be seen that in this way the most accurate results could be arrived at, all the weights being known, and the conditions of load absolutely unchanged. This programme was interesting enough, but it was rendered still more so by the courtesy of Mr. Aveling, who sent his 10-horse engine with iron wheels to take part in the trials; an opportunity was thus afforded of comparing not only india-rubber and iron wheels, but india-rubber and two distinct varieties of iron wheels together.

About 11 A. M. the Sutherland left the show-yard drawing behind her 3 wagons loaded with pig iron and 1 portable engine. The Sutherland weighed 10 tons 6½ cwt., of which 7 tons 9 cwt. were supported on the driving wheels. The gross load to be moved, including the engine, was 36 tons. No difficulty was encountered in hauling in fast gear this load to the toll-bar, the road being all level, or down hill. Messrs. Aveling & Porter's 10-horse engine followed close behind.

Very little time was lost in getting to work. The engine was brought up to a chalk mark on the bridge wall just beyond the toll-gate, steam was raised to 150 lbs., and the engine started, in slow gear of course, at 11.55.15. She proceeded with her train with great ease up the first 100 yards, grade 1 in 35; the second length was equally well done. At 800 ft. from the starting point, the road being a little greasy, the wheels slipped slightly, but nothing of consequence, and, in short, the summit of the incline was reached in 10 min. 45 sec. after starting; steam was easily maintained at 145 lbs. throughout. It was evident that the engine was not fully loaded. At the top of the hill the train was parted in two. The Sutherland proceeded with 2 wagons, made a sharp turn, and descended the hill, while the 10-horse (Aveling) engine returned with the portable engine and the other wagon. Much inconvenience was caused by the crowded condition of the road in moving the engines and wagons, frequent stops having to be made for horses. One lamp post was knocked down, and 1 little boy run over by a light cart, but no serious accident of any kind took place, although 2 engines and a heavy train occupied one of the most crowded roads in Staffordshire for a whole day, surrounded by a crowd of children, who could not be kept out of the way.

As it was evident that the Sutherland had not been fully loaded in the first experi-

ment, Aveling's 10-horse traction engine was thrown out of gear and attached to the end of the train, which now consisted of 3 wagons and 3 engines, the whole weighing 48 tons nearly. The Sutherland started with steam blowing off at 150 lbs., and traversed the first 300 ft. all right. She stopped by slipping her wheels on the second 300 ft. length, the incline being 1 in 20. The portable engine was then detached and the load thereby reduced to 43 tons. With this she proceeded until the incline of 1 in 18 was reached. Up this she could not get, the wheels slipped, and so ended the experiment, which proved that the maximum tractive force which the india-rubber tires would permit the engine to exert would suffice to take something more than 36 tons, and something less than 43 tons up an incline of 1 in 18. The limit of adhesion may be taken as reached with a load of 38 tons.

The next step was to bring the train back to its old quarters at the toll-gate. The 10-horse engine went to the assistance of the Sutherland, and what might have proved to be a very serious accident took place. As will be seen in our impression for June 30th, the Sutherland was fitted with a fly-wheel near the ground at the back. In parting the train the 10-horse engine unfortunately pushed a wagon against this fly, then revolving rapidly. The fly immediately flew into a hundred pieces, some of them cutting up the road right and left. Fortunately there was no one close at the time, and no harm was done. The wheel was not wanted on the road, and should have been removed beforehand. After this little episode the train was re-made up as before, with this difference that Messrs. Aveling & Porter's 10-horse power engine was substituted for the Sutherland, which returned to the toll-gate to have the wheels changed. The new engine weighed 11 tons 4 cwt. 3 qr., or nearly 19 cwt. more than the Sutherland. The total weight on the driving wheels—which are 6 ft. high and of cast-iron, rising 1 in. in the centre of the rim, which is fitted with a middle ring and diagonal crossing pieces, and is 18 in. wide—was 8 tons 10¼ cwt., or 1 ton 1 cwt. 1 qr. more than that on the drivers of the Sutherland, which were besides only some some 5 ft. high.* The engine started easily on the first 100 yards with 3 wagons, but she did not obtain her full load until the portable which had been left standing in the road was coupled on at 500 ft. from the starting point. The load was now precisely the same as that taken up by the Sutherland, plus 19 cwt. extra weight of the engine. A start was now made in fair style, and the engine proceeded tolerably well, slipping a good deal, until the 1,600 ft. point was reached. The incline here is only 1 in 22, and the engine had already managed to get over 1 in 18. But here she stuck, evidently because the wheels had been worn bright by constant slipping. The jack-in-the-box gear gave trouble, too, as it was impossible to keep both drivers revolving together. Mr. Aveling dexterously got over this point by putting a cold chisel into the compensating gear, with this result that the engine then slipped both wheels instead of one; cinders, gravel, old bricks, etc., were thrown under the wheels, and, after a hard struggle, the engine at last hauled its load to the top of the incline, having occupied, in doing a distance 500 ft. less than that traversed by the Sutherland, 29 min. 15 sec. If the iron-wheeled engine had gone over the whole distance worked by the india-rubber engine it would have occupied 40 min. Although the 10-horse engine got up the incline once, it is certain that it could not have got up the second time, as having brought the train to the bottom of the hill, she was unable to turn it into position owing to the slipping of the wheels.

By this time the Sutherland's change of wheels had been effected. It was judged expedient to begin with a light load. The wheels weighed 26 cwt. each, against 15 cwt. each for the india-rubber. The weight for adhesion was, therefore, greater with the cast-iron wheels. The load selected, however, consisted of 2 wagons and the portable engine, the gross weight moved being only 28 tons 4 cwt. With this the engine proceeded to ascend the incline with difficulty, but got on by the constant use of gravel thrown under the wheels. The 1,500 ft. mark was reached—1 in 18—but beyond this point nothing would induce the engine to ascend

* The position of the engines on the incline slightly augmented the weight on the driving wheels by throwing the water further back in the boiler and the tender, but inasmuch as they both lost 1-18th of their whole weight when standing on an incline of 1 in 18, we have not thought it necessary to use any other figures than those obtained at the weigh-bridge.

—not even coal sacks thrown under the wheels. The portable engine had to be detached, and the Sutherland reached the top with but 2 wagons, in 28 min. after starting. No more conclusive proof of the superiority of the india-rubber tired wheels was necessary. The day was far advanced, and so the experiment terminated with the return of the wagons and engines to the show-yard.

Let us see what are the deductions to be drawn from these experiments. They are—(1) India rubber tires may be depended upon to take with certainty a gross load equal to 5 times the insistant weight on the drivers on a level up inclines of 1 in 18 on good roads; (2) cast-iron tires with cross ribs and narrow central bearing rings, which are found to give more adhesion than wide wheels, cannot be depended upon to take more than 3.75 times the insistant weight on the drivers on a level up an incline of 1 in 18; (3) smooth cast-iron drivers 5 ft. diameter, and broad in the face, cannot be depended upon to take as much as 3 times the insistant weight on the drivers on a level up inclines of 1 in 18; (4) the adhesion of both forms of tire is greatly reduced by the polish imparted to the wheels by slipping; (5) this does not seem to apply to india-rubber tires, the bite of which is apparently a constant quantity, irrespective of polish in the chain; (6) on hard roads the friction between the wheel and the rubber is slightly greater than the friction between the tire and the road.

As regards the coefficient of friction, it is not very easy to arrive at a definite conclusion. The resistance due to gravity of a train weighing 36 tons, and starting on an incline of 1 in 18, is 4,480 lbs. Assuming the resistance due to road friction to amount to 40 lbs. per ton—and in this case it could not have been less—we have a gross resistance for the engine and train of $4,480 + 1,440 = 5,920$ lbs. The load on the drivers standing on an incline of 1 in 18 amounted in the case of the Sutherland to 15,868 lbs. This, divided by 5,920, gives a coefficient of $\frac{1}{3.7}$ for the work actually done by india-rubber tires. About the Aveling engine it is yet more difficult to speak. Not only is there room for doubt as to the actual road friction resistance, but there is also a doubt as to what is admissible in the way of slipping. Assuming that Aveling's engine got up just as well as the Sutherland with 37 tons gross load, we have 5,984 lbs. as the gross resistance; and this divided into the gross load on the drivers, amounting on an incline of 1 in 18 to 17,982 lbs., gives as nearly as possible 3 as a quotient. Therefore the coefficient of adhesion of cast-iron tires would be $\frac{1}{3}$. But as a matter of fact the 10-horse engine only got up the incline with the aid of sand, cinders, and broken bricks and stones. The engine had to be detached from the train at one place to enable her to get on new ground, a long chain being used to connect the two. Besides, as the wheels become brighter and brighter, they had less and less adhesion. Under the conditions, we believe it would be wrong to assume that the coefficient of adhesion is greater than $\frac{1}{4}$ of the insistant load, provided no sand or other means of obtaining adhesion be used. The coefficient of smooth iron wheels is very much less, but no data are supplied by the experiments of Saturday, going to show precisely what it is.

Professor Wagner, in his reports, says that the manufacture of iodine from Chili saltpetre already amounts to 30,000 lbs. per annum. The method invented by Thiercelin for its reclamation from the crude material is as follows :—The mother liquors resulting from the manufacture of saltpetre are treated with a mixture of sulphurous acid and sulphite of soda, in proper proportion, and the iodine will be precipitated as a black powder. The precipitated iodine is put into earthen jars, on the bottom of which are layers of quartz sand, fine at the top and coarse at bottom; from this it is removed by earthen spoons into boxes lined with gypsum, and a greater part of the water thus removed. It is sometimes sold in this impure state, or further purified by sublimation.

At the Upper Forest Tin Works, near Swansea, Messrs. W. Hallam & Co. have rolled the thinnest sheet of iron ever produced. It requires 4,800 such to make an inch in thickness.

The fourth volume of the "Coal Plants of the Illinois Geological Survey" embraces descriptions of 78 new species.

NARROW GAUGE RAILROADS.

By HORATIO SEYMOUR, Jr.

In a report upon narrow gauge railroads, read before the British Association by Mr. Fairlie, he says: "It ought to be engraved upon the mind of every engineer, that every inch added to the width of a gauge beyond what is absolutely necessary for the traffic, adds to the cost of construction, increases the proportion of dead weight, increases the cost of working, and, in consequence, increases the tariffs to the public, and by so much reduces the usefulness of the railway." He further adds: "In moderate, temperate climates, gauges of 2 ft. 6 in. will be found ample for any traffic in any part of the world, and will sustain a speed of 30 miles an hour; while 3 ft. is sufficient for either very hot or very cold climates, and will sustain a speed of 40 miles an hour."

The author then went on to make a comparison between the North Western Railroad of England, the best managed road in the world, as it now is, a 4 ft. 8½ in. gauge, and what it would have been had it been made a 3 ft. gauge, proving that there would be a saving of ½ in the expenses of running the road.

I apply the same reasoning to American railroads, both as to the making and running them.

I take the 3 ft. gauge, both because of the severity of our climate, and because the time that can be made on it compares favorably with the time made on our fastest roads.

The chief difficulty of building railroads is their cost; and this difficulty hinders the making of roads which would pay well if they were built.

It is rarely that we find a road being built and equipped for less than $33,000 or $34,000 per mile, a rate at which a road 30 miles long would cost $1,000,000; a large sum of money for a community to raise, and capitalists are not wont to invest such sums in an enterprise which, taking 2 or 3 years to complete, will only, after its running, bring them at the most 7 per cent interest.

But if we can build a road which has equal capacity with any other, both for carrying freight and passengers, upon which equally fast time can be made, for 60 per cent. of the cost of the 4 ft. 8½ in. gauge, and its construction shall be such that after it is built it shall cost but half as much to run it, then the difficulty in raising money is in a great measure removed.

I will show that the 3 ft. gauge makes this reduction in cost, and will do so in detail.

There is a necessity for only ⅗ths the amount of land now taken for right of way.

The amount of cutting and embankment to make the road bed would be but ⅗ths, while the location of the narrow gauge, by running sharp curves, will cut down this, the great cost of construction, in rough countries, according to English engineers, to about 25 per cent. of the cost of the 4 ft. 8½ in. gauge.

The width of the bridges and culverts may be diminished in the proportion of 3 to 5.

The ties may be shorter.

The rail will weigh but 37 lbs. to the yard, in place of the 70 lb. rail now in use. The 37 lb. rail is now used on 2 narrow gauge railroads in Sweden.

The locomotive may be made to weigh between 6 and 20 tons, in place of the 20 to 40 ton locomotives now in use.

The cars not only may be but ⅗ths of the size of the cars on the broader gauge, but they may be made lighter in every way.

Buildings may be made much smaller, though the reduction in cost may not be as great as ⅗ths.

Turn-tables may be smaller in the same proportion.

The time required to build the road will be shortened ⅖ths, and thus give a quicker return for the money invested.

The cost of supervision will be less in proportion.

We have seen that on a road of 3 ft. gauge, the right of way, the culverts and bridges, ties, rails, and locomotives, turn-tables and cars, interest on investment, and cost of supervision, would all be reduced ⅖ths; while in the cost of earth moved there would be a reduction of ⅗ths; the buildings would only be reduced perhaps ⅛th; giving in all a saving of ⅔ths of the cost of the 4 ft. 8½ in. gauge.

Experience has proved the statement to be true. A Russian commission certified to it. In Norway, 2 railroads of 3 ft. 7 in. gauge were constructed by Mr. Pihl; one at Storen, and the other at Hamar; the Hamar line cost £3,000 per mile, the Storen £5,000 per mile; during the building of these roads, and within a few hundred miles of them, a road was built on the 4 ft. 8½ in. gauge, the rate of wages being the same on the 3 lines. The 4 ft. 8½ in. gauge road cost £6,400 per mile, thus showing a saving in the case of one of the narrow gauge roads of £1,400 ($7,000) per mile, and in the other of £3,400 ($17,000) per mile, an average saving of ⅔ths in favor of a narrow gauge, which was 7 in. broader than the one we propose.

The next point to be seen is, whether we can make good our statement that the 3 ft. gauge can carry an equal amount of freight and passengers with the 4 ft. 8½ in. gauge, and at the same speed. The Fairlie engine upon the Festiniog Railroad, in Wales, on a gauge of only 2 ft., drew 500 tons on the level, and over the whole road, around curves of only 116 ft. radius, and on a grade of 71 ft. to the mile, drew a load of 206 tons during a trial trip made before a Russian commission. The average weight of freight trains, including freight and locomotive on the New York Central is 360 tons, according to their report of 1868.

The highest rate of speed made on the 2 ft. gauge is 30 miles an hour, but the engineer says he can make 40 with perfect safety. On the Ullinbord road in Sweden, a 3 ft. 7 in. gauge, 35 miles an hour has been run with a 12 ton locomotive.

The British Association reports say that on a 3 ft. gauge, 40 miles an hour may be run.

On the Festiniog Railroad, during the year 1868, 130,000 tons of goods and 145,000 passengers were carried. This road is only 13 miles long. In the same year the Syracuse and Binghamton Railroad, which is 81 miles long, carried 424,537 tons of freight, and 245,577 passengers.

The Black River and Utica Railroad, which is 86 miles long, carried in the same year 25,403 tons of freight, and 100,111 passengers.

The Ullinbord Railroad, in Sweden, which is 23 miles long, of 3 ft. 7 in. gauge, reports a business of 100,000 passengers, and 150,000 tons of freight a year.

The cost of maintaining a road must depend upon the amount of weight the road bed has to carry, since the cost of repairing it is as compared with all other repairs nearly 3 to 1.

The New York Central report for 1868 gives the cost for keeping up the permanent way as $3,000,000 to $1,000,000 for all other repairs.

If we can reduce the weight that a road bed has to sustain ½, and not reduce the amount of freight, and at the same time increase the durability of all the materials composing the road, as well as the running machinery, we have cut down the cost of operating the road just ½.

The ordinary box freight car of the New York Central weighs 10 tons, and carries 10 tons; the average number of cars in a train is 18; 18 cars weighing 10 tons each and each carrying 10 tons, would give a load of 360 tons as the average weight of a loaded train; of this 360 tons, 180 tons is non-paying weight. Taking the number of cars that run half full, and the number that run half of the way empty, may we not estimate that the Central carries a proportion of 2 tons of non-paying load to 1 of paying?

The Festiniog Railroad uses cars weighing only ½ a ton, carrying a load of 3 tons, a proportion of 6 tons of paying load to only 1 of non-paying. John B. Jervis has built cars weighing 3 tons which carry 7 tons. The Norway roads build cars weighing 3 tons which carry 6 tons. In the case of the Festiniog road, the paying weight was as to the non-paying weight relatively 12 times greater than that of the New York Central, and in the case of the other roads it was 4 times that of the Central.

To make as safe a calculation as possible, we will say that cars can be made for the 3 ft. gauge weighing 3 tons which can carry 6. The total amount of freight or paying weight carried on the New York Central in 1868 was 1,846,000 tons; to carry this, assuming that the cars ran full both ways, an equal amount of non-paying tons (the weight of the cars) has to be drawn over the road. On the narrow gauge road, if the same amount of freight was carried, only 923,000 tons of non-paying load would have to be drawn, a saving of 923,000 tons, which the New York

Central has to carry at a dead loss. In fact the loss is twice this, as the cars are not loaded for more than ½ the distance. As it costs the road $1.58 to transport a ton, the hauling of these non-paying 923,000 tons costs the New York Central $1,458,340 a year.

There are other benefits arising from the use of small, light cars. They can be handled with greater ease. Friction, both of the rails and axles, increases directly as the weight. The jar or blow which the car receives from any unevenness in the track, or want of uniformity in the wheels, is increased by the weight.

The decrease in strain on machinery from having the points of support nearer together is immense.

So far we have been considering freight cars; the same reasoning applies to passenger cars, which weigh, on the Central, about 18 tons each, and are made to carry 50 passengers, although the average number in each is about 25. On the Norway 3 ft. road, the cars carry 28 passengers, and weigh 4 tons, while on the 4 ft. 8½ in. gauge, in the same country, the cars carrying only the same number of passengers weigh 6 tons; 28 passengers in a car weighing 4 tons would give 300 lbs. of car for each passenger. Giving 400 lbs. of car weight to each passenger, a car could be built that would carry on the 3 ft. gauge 30 passengers, and be but ⅓ the weight of the Central cars. An 18-ton car carrying 50 passengers, would give to each person 720 lbs. of weight of car; while in a 6-ton car, carrying 30 passengers, the weight per person would only be 400 lbs., a saving of 320 lbs. per man, which in a car carrying 50 passengers would amount to 16,000 lbs., which are like, it has been aptly said, so many dead-head passengers that never get out.

The great objection urged against the construction of narrow gauge railroads is, that as the main lines are all 4 ft. 8½ in. gauge, if the branch lines are of a narrower gauge, the freight must be all reshipped at a large cost. This is a disadvantage, but the amount of cost of transferring freight is greatly overestimated.

The engineer of the Ullinbord Railway in Sweden found the cost of transferring to be but 2 cents per ton, since the labor was not great when cars were placed alongside of one another.

We read every day of some 6 ft. gauge being changed to 4 ft. 8½ in., and perhaps as the world improves we shall see railroad companies consulting their interests, and changing to a 3 ft. gauge.

STONE CAISSONS.

From "Engineering."

A number of gentlemen, including in their number Gen. Strachey, Mr. Juland Danvers, Mr. A. M. Rendel, Mr. W. J. Thornton, Mr. J. Cubitt, Mr. C. Hawkesley, and others, were received at the works of the Ransome Patent Stone Company, by Mr. H. Bessemer, the Chairman, to inspect some stone caissons now being made, to be used in the construction of the quay at Hermitage Wharf, near the Thames Tunnel pier. The opinion universally expressed was favorable to this new application of the Ransome stone, but of course the test of experience must be applied before any definite conclusion can be arrived at. If, however, it should be found successful, and we have little doubt it will, this application of Mr. Ransome's stone, made under his patent of last year, to the construction of foundations for piers, bridges, river walls, and all kinds of hydraulic works, will be possessed of the most important advantages, which can scarcely be over-estimated.

The rapidity and ease with which blocks of any form, and the sizes of which are limited only by the means available for handling them, can be produced upon the spot where they are to be employed, are advantages sufficiently great to warrant their adoption. And when, in addition, it is remembered that the materials which form the base of the Ransome stone exist in most instances in embarrassing quantities upon the site where hydraulic works are carried on, and that these, by the combination of other elements, are converted almost immediately into a stone, the strength of which is surpassed only in a small degree by granite, it will be admitted the advantages obtained are almost incalculable. This application of Mr. Ransome's process

has been suggested by Mr. Butler for two reasons: the first, to provide a cheap and thoroughly efficient substitute for stone for hydraulic works; the second, to render unnecessary the construction of false works, coffer-dams, etc., and to avoid the employment of iron cylinders and caissons, now of necessity so extensively used.

In order to obtain perfectly reliable data as to the powers of resistance of Mr. Ransome's stone, a valuable and exhaustive series of experiments was recently carried out, and the result of these experiments showed that the average power of the stone to resist a crushing force was 3.19 tons to the sq. in. It should, however, in justice be remarked that this average was reduced by the fact that some of the stone blocks tested were composed of materials which necessarily gave a comparatively low result, and that the average strength of the stone manufactured in the ordinary manner, gave an ultimate strength of 4 tons per in., which may be assumed as the average strength of the stone.

Compared with some of the best natural constructive materials, the strength of the Ransome stone stands thus:

Granite, resistance to crushing, 8,000 to 12,000 lbs. per sq. in.

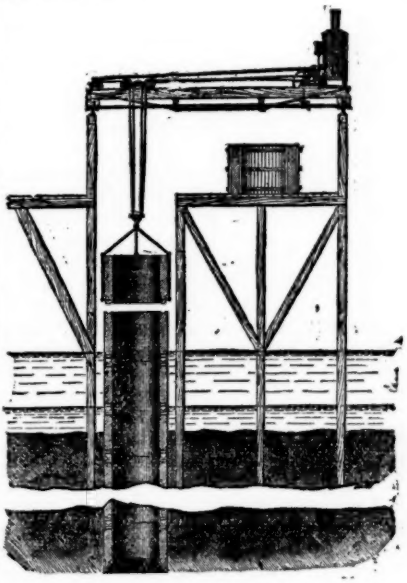
Portland stone, 2,630 lbs. per sq. in.

Bramley Fall, 5,120 lbs. per sq. in.

The Ransome stone, 8,960 lbs. per sq. in.

It will thus be seen that the Ransome stone is, so far as strength is concerned, one of the most suitable of all building materials, and being perfectly homogeneous, it is thoroughly reliable. With regard to its durability, it is sufficient to point out that its constituent elements, and the manner in which the concretion of the entire mass is effected, guarantee for it a hardness and durability scarcely to be met with in any other material, whilst its uniformity of color and texture render it also peculiarly suitable for the new purpose for which it is now being applied.

In practice, the materials forming the stone will be moulded *in situ* into blocks, either solid or cellular, of the required shape and dimensions. The cellular blocks form, however, the special peculiarity of this system. For bridge piers and abutments the blocks may be rectangular or circular, for dock and river walls they may be square or hexagonal—in fact, any required shape may be given them. If found advisable, they may be stiffened internally with iron braces, but this would be seldom necessary, as the strength of the material will be found sufficient, unless in very exceptional cases. For convenience in sinking the blocks (an operation which is precisely similar to that employed in sinking iron cylinders) the lower edge of the bottom length would be chamfered, and, when necessary, shod with iron. The horizontal joints would be made preferably with alternate projections and depressions in the sides of the blocks, and the vertical joints are made good with timbers halved into each block. But these joints may be effected in a variety of ways, which need not be specified here.



What is specially urged for this system is, that it is a simple and reliable utilization of material thoroughly adapted for the purpose, that it provides a cheap and efficient substitute for the present costly means of sinking foundations, and it is confidently believed that by its application a great revolution will be effected in the construction of hydraulic works.

It need scarcely be explained that, in nearly all cases, the stone blocks, or caissons, form their own coffer-dams, whilst

in those exceptional instances, where temporary works are required, their extent and cost would be reduced by the new system.

It is also evident that there are few circumstances under which the process described, or modifications of it, would be inapplicable, whilst its cost, even under the least favorable condition reduced to half that of the existing modes of construction, would, in situations where skilled labor is scarce, and materials and the means of transit costly, be further reduced to a far larger extent.

THE BUILDING ARTS OF RUSSIA.

From "The Builder."

Marble enters very sparingly as yet into the composition of private buildings in Russia. There was an exhibitor from Moscow who had samples of marble work, the raw material being obtained in the neighborhood of that city, and called Padolian marble, a gray species. The prices attached to the specimens were as follows: Steps, per archine ($\frac{3}{4}$ yard) in length, 5 r. s. (12s. 6d.) polished, 4 r. s. (10s.) unpolished; landing slabs, per sq archine, polished, 5 r. s. (12s. 6d.); plain, 3 r. s. (7s. 6d.). Window-sills, polished, per vershok ($1\frac{3}{4}$ in.), 1d. The finer qualities of marble (raw material) are all imported, on which there is no duty. The working of stone in Russia is effected entirely by hand labor; but there is no doubt that with the increase of the material prosperity of the country a demand will spring up for some of our machinery, which has been lately introduced for the above purpose. There is already one establishment at St. Petersburg where stone is dressed by machinery. The museum of the School of Mining sent to the exhibition specimens of jasper, porphyry, marble, agates, etc., in the raw state, obtained from Siberia; but these materials are as yet too expensive to be applied for architectural purposes, even in the houses of the most wealthy. Specimens of their application, on a large scale, for the above purposes (decorative architecture), are to be seen only in the Imperial palaces, such as those of Tsarskoye-Selo, near St. Petersburg, where the interior offers enormous treasure and splendor. There are chambers of amber, mother-of-pearl, jasper, porphyry, and agate; colonnades of malachite, mosaic pavements, etc.

Notwithstanding the abundance of malachite found in the Ural Mountains, it is rarely to be seen in the shape of doors and mantel-pieces, such as were exhibited in the London Exhibition of 1851. The price quoted for raw malachite by Mr. Demidof at the late Russian Exhibition was 125 r. s. per pood (£1,030 per ton).

No modern city can boast that it is so entirely composed of colossal buildings as St. Petersburg. The Winter Palace, for instance, has 6,000 inhabitants. In the Infantry Hospital several thousand beds are made up. In the Foundling Hospital there are many thousand children. There are single houses from which their owners derive princely revenues. The ground which is occupied by the Corps of Cadets forms a square of which each side is about a quarter of an English mile in length. There are other buildings, such as the Admiralty, the Hotel de l'Etat Major, the Gastinny Dvor and other markets,—buildings which occupy space enough for a small town. It was the custom formerly to build private houses, occupying an enormous area, no higher than 2 floors; but, with the increase of the value of land in the capital, high buildings became indispensable, so that they are now constructed from 3 to 6 stories high. The styles adopted at St. Petersburg for private and public buildings are varied. The building of a house in St. Petersburg is always done by contract, under the superintendence of a qualified architect, who is subject to the Government architect and surveyor, whose business is to watch the operation of construction. The erection of a house is a much more costly undertaking in St. Petersburg than in any other part of Russia. Provisions are dear, and the price of labor is always comparatively high. The building can only take place in the summer months, which necessitates the employment of an extraordinary

number of workmen, who engage by contract for the whole term, when the wages are paid, the contractor providing lodging and food. As a rule, the houses are well built, with brick walls, a desideratum in a cold climate. The staircases are invariably of stone; and considering the primitive nature of the tools and appliances of the workmen, the work is rapidly executed (the hours are from 3 in the morning till 8 at night, out of which 2 hours' rest is allowed after dinner). The Russian trowel is only the size of those used by plasterers in this country, and of the same shape; and for the batting of the bricks a separate instrument is employed, somewhat in shape like a plasterer's hammer. The spade used is of wood, tipped with iron. Nearly all the wooden appliances are knocked together on the spot, such as troughs and barrows. Of the latter, the iron wheel and axle are the only parts which are carried from place to place. Ladders are also knocked up on the spot. The bricks are carried on the back, on a kind of stand, with curved arms, which rest on the shoulders; and the mortar is trodden with the feet, to the rumation of the boots of the poor workmen. This primitive mode of contion all adds to the cost of building in Russia. The introduction of appliances and machinery, such as proper windlasses, hoists, mortar-mills, etc., would be of incalculable benefit, both to the workmen and employers, considering that building in the capital is always conducted on an extensive scale. One of the terms which is strictly enforced at St. Petersburg is the covering of every dwelling-house with stucco, which must be colored, and kept in constant repair, as the climate acts very disastrously on the appearance of the houses. Almost every spring the stucco peels and tumbles off; and nothing has so disagreeable an effect as Corinthian or Doric columns, which, in dilapidated buildings, expose in patches the red brick of which they are constructed. This is constantly to be seen in the provincial towns. Another feature of Russian architecture is the class of summer residences in the neighborhood of St. Petersburg. Every one who can afford it leaves the capital for the summer months. The poorer classes resort to the villages in the vicinity, and the rich to the country houses, called datchas. They are generally built on the banks of the Neva, and are of wood, in all manner of styles. Gothic, Italian, and even Chinese specimens are to be found, of the taste of all ages. Although they have generally cost enormous sums in the erection, and display much luxury, we should look in vain for the architectural grandeur of the Italian villas or the comfort of English country houses.

One great characteristic of the Russian building art is church architecture, of which Moscow and the ancient towns Kief and Novgorod contain remarkable specimens of what is called Russo-Byzantine style, of which one of the chief features is the towers surmounted with the cupolas in the form of a bulb or onion, not unlike those of the Pavilion at Brighton, on the top of which is a cross. With a general similarity in appearance, the form of the towers varies considerably, striking the eye by their irregularity and their diversity of colors and gilding. It is to this particular that Moscow owes its remarkable appearance. It would appear altogether that very little attention has been paid in Russia to the studying of their ancient church architecture, or archæology, generally speaking, until quite recently, when the initiative was taken by a private gentleman, Mr. Prokhorof, who undertook on his own account the publication of a work entitled "Antiquities of Christendom and Archæology." It contains, among other things, etchings of interesting specimens of frescoes of the 12th century from the Church of St. George at Staro-Ladoga or Ruric's Fort. Following in the footsteps of the above gentleman, the Moscow Architectural Society have despatched several of their members for the purpose of illustrating ancient Russian sculptural monuments, particularly in the ancient towns of Pereslavl-Zalessky, Rostof, and Yaroslaf. Photographic views are to be taken of the exteriors of the churches, from parts which have been the least subject to innovation, and of the interiors. It is the intention of the Society to form a gallery of these photographs, the first of its kind, at the forthcoming Moscow Technical Exhibition of 1872.

At the St. Petersburg Exhibition were to be seen some plaster casts of frescoes in the Russo-Byzantine style, together

with a fac-simile of the doors of an Ikonostas, or altar-screen, taken from the ancient church at Suzdal, which attracted much notice.

The church architecture of St. Petersburg differs from that of the old towns. It has neither so many nor so distinguished churches as Moscow, although the major part are built in a pleasing and tasteful style—in the modern Russian, which is a mixture of the Grecian, Byzantine, old Russian, and New European architecture.

The St. Petersburg Exhibition, in an artistic point of view, presented far more important features than the Russian department at the Paris Exhibition of 1867. Not only separate articles, but whole groups of objects, forming of themselves already complete and distinct exhibitions, appeared here with characteristic and remarkable originality. Of these, carvings in wood were particularly noticeable. The Russians are masters in wood-work, and a particular kind of artisans in the capitals, and, indeed, in all Russian cities, are the carvers in wood. It was to be expected that among the inhabitants of the immeasurable forest districts of Russia a peculiar dexterity in wood-carving would develop itself. The sculptors in wood in the towns are distinguished from the carvers of the villages, who devote themselves principally to the production of articles of domestic use; the former work to a very great extent at the ornamental parts of the interior of churches, where the Russians love to see pomp and splendor, for which an enormous quantity of wood-carving and gilding is required. For fine work the lime is chiefly used. Each workman, when engaged on a piece, has a drawing before him, working on a block of wood with chisel, knife, and hammer, and the dexterity with which he will form the whole figure from a flat picture is remarkable, considering how little he is indebted to any sort of instruction. In church decoration the most striking objects exhibited were the Ikonostases above mentioned. The Ikonostas is a high screen carved in wood and gilt, which separates the holiest of holies from the rest of the church, on which are represented images (paintings) of Jesus Christ, the Virgin Mary, the four Evangelists, and other saints. The drapery of these paintings is made in solid silver and silver gilt, raised and engraved. In the middle are the doors, or Tzar's gates, as they are called, which generally constitute masterpieces of the carving and gilding, of which a specimen was exhibited by a Moscow firm, beautifully formed of golden columns, and mixed and interlaced with vine leaves and ears of corn, richly gilt. Part of an Ikonostas in oak destined for the Russian Church of the Trinity at Jerusalem was also conspicuous. The price of the whole Ikonostas was to be over £1,000.

It is somewhat remarkable, that while various reforms are being introduced in Russia, modelled on those of Western Europe, a complete change has come over the taste in ornamental art. The Roman, Greek, and Italian French styles are being abandoned, and a purely national taste is cultivated. This was apparent at the Exhibition; in fact, may be regarded almost as a sort of fanatical patriotism, and a curious instance of this spirit was noticeable some time ago in the Strogonof School of Des gn, in Moscow (containing 200 scholars). In that school, the pupils who learnt landscape drawing were to copy nothing but Russian landscapes. Those who studied flowers were to embody in their designs Russian flowers only; while designs of a more complex character were taken from Russian illuminated missals, or other works of Russo-Byzantine art. With regard to the latter, a very interesting work has been published and executed in Paris, from the designs by the pupils of the above school, taken from Russian illuminated manuscripts, entitled "History of Russian Ornamental Art, from the Tenth to the Sixteenth Centuries." This publication should claim the attention of our own designers and architects, as being novel, and the designs applicable to the ornamental art of this country—the innumerable figured patterns and ornamentations shining in splendid colors, sometimes on a golden ground, with endless and varied plait work and geometrical figures of the most wonderful kind, all this in combination with leaflets, flowers, stalks, and twigs, and strangely intermixed forms of dragons, affording rich material for the artist and artisan. The Count Strogonof School of Design has already considerable influence on the development of native industry, and produces a large number of designers, who find ready employment in Moscow. A useful work

has just been published, entitled "A Guide for making Russian Designs."

Besides drawings and plaster casts of ancient Russian architecture, there were exhibited by the same school very fine specimens of painting on china, delf, enamelled iron, flooring tiles, etc. In the department for wood carvings, there were some fine specimens of Russian woodwork, fretcutting, with curious carving, notably the kiosk, where Bibles were offered for sale, and the pavilion containing Mr. Tatischef's collection of Russian woodwork, a case in the form of an izboushka (a little izba), containing samples of macaroni, a garden pavilion, finished with a kind of wood tissue.

As to Heating and Lighting.—In general the Russian stove is a large, clumsy, oblong mass that rises nearly to the ceiling of the room, to which it is a disfigurement rather than a decoration. It is these drawbacks that have lately been noticed by Russian builders, and in some of the modern houses a kind of compromise has been effected between the Russian stove and the English fireplace, which, as regards cheerfulness, is certainly an improvement. English fireplaces, with marble chimney-pieces and fire-irons, etc., are occasionally imported, but the duty and expenses are too high to make them a regular article of traffic. The Russian stove as at present constructed, of white glazed tiles, is, doubtless, of Dutch origin, as the shape and size of the tiles is that which prevailed in Holland about 2 centuries ago; they are clumsy in appearance, heavy, and quite unsuitable for any kind of ornamental work. At the Exhibition some of these tiles were shown: white, at from 7 copecs (2¼d.) to 15 copecs (5d.) each; and of a red color, 3 copecs (1d.) to 6 copecs (2d.) each. There is this peculiarity to be noticed in the glazed tiles manufactured in Russia—after being a short time in use the enamel invariably cracks all over, presenting a very unsightly appearance. There is another kind of Russian stove which is fast superseding the one just mentioned. It is of a cylindrical form, and is constructed of red brick, covered with sheet iron. It is cheaper than those constructed of glazed tiles, but does not retain the heat so well; and its gloomy appearance, and when the dark green color with which it is generally painted has been burnt and blistered, tends considerably to mar the *tout ensemble* of the apartment in which it is erected.

The cooking stove or *plita* used in the capitals has now almost entirely superseded the old-fashioned Russian *pech*. The former is fashioned somewhat like our kitcheners, but they have this advantage that they can be approached from 3 sides; it consists of a thick iron plate set in brick and glazed tiles, with baking oven. Taking it altogether it is a clumsy contrivance, and takes up a great deal of room. It is used for boiling, frying, and baking; appliances for roasting are not known except in a few of the elaborate kitchens of rich Russian gourmets. The pech is very much like a baker's oven, the whole arrangement being very primitive, besides consuming an inordinate quantity of fuel.

In the heating of a Russian stove, pine, fir, and birch wood are principally used; and it should be remarked that the embers play a most important part, for it is from the embers, not from the flame, that the stove is expected to derive its heat. So long as the wood continues in a blaze, whatever quantity may have been put in, the stove never gets thoroughly warm; it is only by means of the "viewshka," a sort of double flue plate, that the passage from the stove into the chimney has been hermetically closed that the heat begins to be sensibly felt in the room. The Russian stove-heaters are extremely dexterous in all the details of their occupation. Tongs and shovels are unknown to them. Their only instrument is the "kocherga," a long iron poker, with a hook at the end of it. With this they keep up stirring the fiery mass, break up the embers, and pull forward the fragments of wood that are still burning, in order, by exposing them to a current of air, to accelerate their conversion. In every great house there is at least one servant whose exclusive duty is to look after the stoves, and he collects and prepares the requisite fuel. In general he builds up a pile of logs within each stove the evening before, that the wood may be well dried, and then he sets fire to it early the next morning, using for that purpose the tarry rind of the birch. If the "viewshka," or damper, be closed before the wood be completely burnt into embers, a poisonous gas is emitted by the coals, and

fatal consequences may ensue to those who are exposed to its influence; the blue flame hovering over the bright embers is therefore carefully watched, and not until it entirely disappears is it considered safe to close up the stove. Accidents do occasionally happen, and it is nothing uncommon in Russia to hear of people who have been suffocated by the fumes of their stoves; but when the immense number of these stoves is taken into consideration, and that every floor and every part of the house has to be heated at least 6 months in the year, it must be admitted that accidents occur but rarely, and that an admirable degree of care is displayed in thus always selecting the proper moment for closing the "viewshka."

The attention of Russian specialists has lately been directed towards the discovery of means of effecting economy in fuel, which is an important and expensive item in every Russian household, the reckless manner in which woods have been destroyed causing no little anxiety concerning the future supply. When we consider that the winter lasts 6 months, and that, at St. Petersburg, where the climate, although somewhat modified on account of the proximity to the sea, the thermometer, in winter, often points to 55 deg. of Fahr., the imperative necessity for an improved state of things in this department is self-evident. At the Exhibition was shown a stove built, or rather cased in glazed tiles, with hermetical doors, adapted for burning coals, instead of wood,—a decided improvement. The price was 115 r. s. (£14 7s. 6d.). Other stoves of the same kind were exhibited by a maker from Finland, for burning wood, at from 32 r. s. to 92 r.s. (£4 to £11 10s.) each. Iron stoves, of various other constructions, were also shown; but it would appear that in no instance was it demonstrated that the main object had been attained,—the economy of fuel. There were steam-heating apparatus, hot-water apparatus, priced respectively 80 r. s. and 75 r. s. (£10 and £9 7s. 6d.); iron stoves, plain and ornamental, from 50 r. s. to 275 r. s. (£7 10s. to £37); hermetical doors, iron, per pair, from 10 r. s. to 15 r. s. (£1 5s. to £1 17s. 6d.); the same of brass, from 22 r. s. to 30 r. s. (£2 15s. to £3 15s.). As a novelty may be mentioned a portable heating apparatus, heated by means of a "pulverizing lamp," the latter consisting of an adaptation of the principle of the "pulverizer" used by hairdressers, in which the minutest particles of liquid fuel are consumed, a blast being produced by means of an air-pump, which forms part of the apparatus. The merit of this invention consists in the celerity with which water can be boiled—in 2 or 3 min.

Ventilation.—This essential condition of the sanitary economy of buildings has been ever neglected in Russia; and it is only lately that efforts are being made towards providing for this desideratum. It should be observed that the houses in Russia as early as October may be said to go into winter quarters. Double windows are affixed to every room; every aperture through which a little air might find its way is carefully caulked with tow, and then filled up with putty, or pasted over with slips of paper. Here and there a window is so constructed that a single pane may now and then be opened to let in a litte air. In this close and confined atmosphere the family live and have their being till the returning May ushers in the warm weather, and gives the signal that fresh air may again be permitted to circulate through the interior of the house. The Russians have a saying,—"*Par kostay ni lomit*,"—literally "Steam does not break bones," meaning that heat cannot be injurious. This conviction is perhaps the reason why a temperature of 15 deg. Reaumur ($33\frac{3}{4}$ deg. Fahr.) in the bedroom is in no way considered excessive or injurious. There can be little doubt that the lassitude and prostration often experienced during a Russian winter, notwithstanding the invigorating effect of out-door drives or walking exercise in sharp frosts, is attributable in no small degree to the excessive heat of the rooms and the insufficient ventilation. The only ventilator in use, a sort of Archimedean tin fan-wheel, in a case which is fitted into the window or flue. Among the appliances for heating, calorifers erected in the basement of large houses, with a system of flues, have to some extent been adopted in the capital, but it is a question whether they are sufficiently economical to be applied for general use. The Gurney stove has found some favor in some of the larger establishments of the city. Here there is a wide field open for our countrymen. An invention that would

combine economy of fuel with efficiency as to heating would be sure to meet with an enormous patronage all over the empire.

Like all large cities of Europe, the capital of Russia has introduced gas for lighting purposes. Three ineffectual attempts were made to light St. Petersburg with gas before the establishment of the present two companies. The first was during the reign of Alexander I., when, just as all arrangements were complete, the buildings caught fire, and the plan was abandoned for some years. The second attempt was made after the accession of the late Emperor Nicholas. The high and ungainly building intended for the gasholder was injudiciously placed near the Winter Palace, and formed so prominent a deformity that the Emperor was glad, in 1838, to buy up the whole of the premises belonging to the Company, for the purpose of pulling them down. The Company then went to work again, and in the autumn of 1839, when people were beginning to look forward to light streets in winter, the whole illumination was opened and closed on the same day by a frightful explosion, by which the gasholder was destroyed, a number of people were killed, and the money of the shareholders was lost. Shortly afterwards, gasworks were erected in the suburbs by an English firm, which was a complete success, and has continued so up to the present time. It is only recently that another company of the same kind has been formed; the work was also executed by an English firm. The coal is imported from England, and the price of gas per 1,000 about 10s. 6d. It must be admitted that the streets of St. Petersburg, wherever gas has been introduced, are better lighted than they are in London; the number of lamps is greater in a given distance; the burners and quality of the gas is better; the lamp-posts, also, better finished, and certainly ornamental, when compared with the regulation pattern of our metropolis. Gas does not find its way so readily inside the houses; it is confined entirely to the yards, staircases, etc., except in public establishments, shops, hotels, etc., where the fittings are always of the roughest description. Glass globes are never seen on the chandeliers. A short time ago an English company was formed in London—the Moscow Gas Company—who undertook the construction of works in that city. More than 40,000 lamps have already been erected. All the large factories and works in the neighborhood of St. Petersburg have their own gasworks, and they have been introduced in the interior establishments of the same kind, as well as on manorial estates. England supplies nearly all the work.

From lighting we naturally come to paving. The ever-increasing traffic in the capital of St. Petersburg, has called for improvements in paving. Until now almost the only paving-stone known is the common boulder. Many trials have been made to substitute for the old material, iron, asphaltum, granite blocks, macadam, resulting more or less in failures, owing to the action of the frost; as an exception, perhaps, may be taken the wood pavement, which consists of sexagon blocks laid on to 2 in. tarred planks, and secured together by wooden pins, tar being used as a cement. Over this the carriages roll as smoothly as on a tramway. This kind of pavement, however, has only been adopted in some of the principal streets, and necessitates constant repair, owing to the watery soil. The paving of the capital falls to the lot of the house proprietor, who is bound to provide the same opposite his house, and keep it in order. Even the common pavement is dear, notwithstanding the low cost of labor, and of the material, which is gathered in the vicinity, on the coast of Finland; it requires constant repair, owing to the marshy nature of the soil. The winter roads serve to mitigate the punishment inflicted on the traveller in the St. Petersburg streets. Nature has provided, by means of snow and ice, a more convenient road for man and horse than any that art has been able to construct; it is astonishing to compare the wear and tear of a sledge with a wheeled vehicle.

Latterly the introduction of tramways for the conveyance of passengers along the principal streets has proved a boon to the public of St. Petersburg, as well as a commercial success, and is likely to meet with considerable extension. The rails and some of the carriages were ordered from this country. Tramways have also been introduced for conveying goods from the quays to the custom-house.

Iron, as applied in this country for

various architectural purposes, such as girders, house-railings, large bridges, etc., is but very little used in the capital, and consequently in all other towns, as an exception, may be taken the railings of squares and gardens. At the Exhibition there was only one girder exhibited by a Government establishment. The northern side of the Summer Gardens of St. Petersburg is celebrated for its iron railings with its fanciful garlands and arabesques, which, people say, an Englishman once travelled all the way from London to see, and make a sketch of, and then returned, satisfied with his journey, not deigning to cast an eye upon any other monuments of the city. However, it is a very elaborate specimen of iron-founding, and scarcely to be equalled anywhere.

There is only one iron bridge over the Neva,—a very fine sample of modern engineering. Another iron bridge is wanted further up the river, and plans for the same have already been submitted to the authorities. The communication between the two banks of the river is kept up to a large extent by means of pontoon bridges, one of these being ¾ of a mile long.

In a sanitary point of view, St. Petersburg, and, in fact, all Russian towns are in a deplorable condition. Drainage is unknown in the capital, except in the immediate vicinity of the river, which is a serious matter for a town containing something like 700,000 inhabitants, and which is proved by the chronic prevalence of Asiatic cholera. The houses, as a rule, are veritable whitened sepulchres; the effluvium from the latrines and dust-holes is horrible. The general and special smells of St. Petersburg in the spring and summer are hardly to be matched in any part of Europe. It is only within the last few weeks, on the outbreak of cholera, that stringent measures have beeen taken with a view to mitigate the evil to some extent by imposing fines upon the landlords. But all this is useless; and until a proper system of drainage is introduced, matters are likely to remain much in the same condition.

Some few years ago waterworks were established. Until then all the water had to be carried in huge casks from the canals and river. It would appear, however, that comparatively few have availed themselves of the luxury of Neva water brought into the houses, the supply being confined chiefly to the streets, where several public fountains have been erected, from which the houses in the vicinity are supplied.

With the extension of the system of railways the towns of the interior are beginning to wake up also. Finding a necessity for a constant and uninterrupted supply of water, they have introduced waterworks, for instance, in the towns of Vladimir, Saratof, Kharkof, Nijni, and Novgorod. The construction of these establishments in Russia affords many facilities, on account of the numerous rivers, and at the same time great difficulties, owing to the action of the frost upon the pipes if not sunk sufficiently deep. The important town of Odessa is only now beginning to adopt the present system of water-supplying. Situated in a locality where there are neither springs nor rivers, it has until now depended entirely upon well, rain water, and a brackish water supplied from an aqueduct yielding about 300,000 gals. daily.

Among the innovations at St. Petersburg is the appearance of water-carts on the English principle. Appliances for gas-lighting and drainage were not shown at the St. Petersburg Exhibition of 1870.

From "Cosmos" we obtain the information that M. Böttger has produced a new test paper which is highly sensitive towards the alkalies and alkaline earths. The reagent is a magnificent coloring matter, obtained from the leaves of an exotic plant (*Coleus verschaffelti*), upon digestion for 24 hours with absolute alcohol, to which a few drops of sulphuric acid have been added. The paper is prepared for use by the usual process. The color is a splendid red, which passes more or less rapidly into a fine shade of green by the action of the alkalies or the alkaline earths. It is far more sensitive than turmeric; it is unaffected by carbonic acid, and will indicate the presence of the least traces of the carbonates of the alkaline earths in water. A moistened strip of the paper, when held at the opening of a gas jet, immediately assumes a green color if ammonia be present.

TELEGRAPHY—THE PNEUMATIC TUBE SYSTEM.

From "The Mechanics' Magazine."

The history of various attempts to promote means of pneumatic communication has been one of great variety. It is many years since a railway system was started on this plan in South Devon; this, and others, proved to be great failures; too much was attempted, and they were unsuccessful. Had the old experiments commenced from small beginnings, different results might have been achieved. In the present time we have witnessed the failure of the Waterloo and Whitehall line, projected to be worked by the pneumatic system, which, as is well known, came to nothing. Not that its want of success was due to any peculiar or inherent defects in the system itself, but rather to the financial fever that, about the same time, left the money-market in so depressed a state.

The Whitehall scheme was, however, the result of small beginnings, which had incontestably proved the value of a pneumatic system as a means of communication; firstly, by the extensive use the Electric Telegraph Company had made of it for the conveyance of messages for a short distance; and, secondly, by the success, in rapidity and transport, resulting from the adoption of a larger means of communication, for the carriage of mails and parcels by a large under-ground pipe, worked on the pneumatic plan, by means of which carriages running on wheels were easily transported for a considerable distance.

It is, however, with the system adopted by the Electric Company, for facilitating telegraphic purposes, that we now propose to deal, and to show how the system has been worked, how successfully it has been carried on, and to what an extent it has lately been expanded for the public telegraphic business.

Mr. Latimer Clark, Engineer to the Electric and International Telegraph Company, had greatly interested himself in pneumatic communications, and the system now in operation decidedly owes its parentage and success to him. He laid down for the Company a tube from their office in Founders' Court for the transmission of messages from the Stock Exchange. This tube was of lead, $1\frac{1}{2}$ in. in diameter, and perfectly smooth in the interior; the joints being carefully made for that end. This lead tube was laid within split iron pipes, great care being taken with regard to the curves. The engine and vacuum reservoir were fixed at Founders' Court, Lothbury, a vacuum being constantly maintained in the tube. The messages were tightly packed in a cylindrical carrier, having flanges so as to fit the tube; by means of a valve at the sending station the carrier was introduced into the tube, and by the influence of the vacuum in front, and the pressure of air behind, the carrier in a few seconds arrived at its destination. So successful was this application for the purpose of facilitating communication between a branch station and the head office, that it was soon extended to other offices where telegraphic correspondence was equally large.

This plan worked for some time with uninterrupted success, few stoppages ever having occurred. Subsequently, a change was made by Mr. C. F. Varley, who succeeded Mr. Clark as Engineer to the Company. It will be seen that under the original plan it was possible at the head office only to receive messages from the other office. Mr. Varley introduced an improvement, whereby an office could either transmit or receive.

This was effected by having at the head office a pressure, as well as a vacuum reservoir, and by making some alterations in the valve. By inserting a carrier in the tube at the head office, and exerting the pneumatic pressure, it was sent through the tube to the destined station. The head office, therefore, received its carriers from the out stations by means of a vacuum, and forwarded them by means of pressure. The tubes thus became doubly useful, and increased extension became the order of the day; the transfer of the Head Office to Telegraph street simply caused an extension of the tubes, and a transfer of the engine and apparatus.

The transfer of the telegraph to the Post Office introduced an increase in the

extension, and a reference to the accompanying list of tubes in London will show the increase due to the Post Office, marked thus † :—

Return showing the number of Pneumatic Tubes worked on Clarke's System in, London, and the time occupied in the Transmission of Messages.

From Engine Station.	To	Indicated Horse Power of Engine.	Length of Tube.	Diameter of Tube.	Time occupied in Transmission.	
					Pressure.	Vacuum.
			yards.	ins.	min. sec.	min. sec.
Telegraph street.....	Fenchurch street.....	40	980	2¼	1 5	1 20
"	Leadenall street.....	40	659	2¼	0 35	0 38
† "	Baltic Coffee House.....	40	590	2¼	0 35	0 38
"	Gresham House	40	588	1½	0 40	0 51
† "	Threadneedle street	40	566	2¼	0 34	0 48
† "	Threadneedle street	40	559	2¼	0 32	0 45
"	Cornhill	40	490	1½	0 37	0 40
"	Old Broad street	40	370	1½	0 25	0 29
† "	Lloyd's	40	343	1½	0 17	0 25
"	Stock Exchange.....	40	314	1½	0 15	0 15
"	Founders' Court.....	40	223	1½	0 13	0 14
"	Anglo-American Office.....	40	62	2½	0 5	0 6
"	Indo-European Office.....	40	57	2¼	0 5	0 5
"	Engineers' Office.....	40	50	2¼	0 4	0 5
"	South Gallery	40	50	2¼	....	....
"	Intelligence Department...	40	44	1½	0 5	0 6
† "	Metropolitan Gallery'.....	40	29	2¼	0 5	0 4
Total length—yards	.....	....	5,974	....	....	....

On referring to the above list it will be seen that these extensions were to the eastward of the Head Office. The postal authorities, however deemed it expedient to make further extensions westward, and tubes have consequently been laid down from Telegraph street to St. Martin's le Grand (the General Post Office), Temple Bar, and Charing Cross. In this extension, in consequence of the success attending a plan of pneumatic communication introduced by Mr. Siemens, in Berlin, it was determined to use his system, especially as it effected great economy in the laying of the pipes.

Mr. Siemens' plan is different from that we have described, inasmuch as it effects communication with a number of stations in the same route, and acting as intermediate stations; whereas, under the usual system only 2 stations were united. But in Siemens' plan it is necessary either to have a tube following a circular route, and returning to the office whence it started, or to have a double tube. For direct communication to places in the same line, this system seems costly on account of the double tube; but, where the tubes have been laid down in Berlin, the communication makes a complete circuit, starting from and returning to one point, and supplying many intermediate stations.

Instead of the highly-surfaced lead pipe, Mr. Siemens uses a 3-in. iron pipe, carefully jointed; it is found, however, very difficult to obtain these pipes without roughness and excrescences in the interior, which soon damage the carrier.

A pumping-engine, with air-pump, is attached, and begins exhausting the air in the tube, which is open at the adjoining but remote end; it will be seen, therefore, that a carrier introduced at the open end will be propelled forward, and traverse the entire circle. In the original plan the carrier was made to travel from station to station, messages being taken out, and fresh ones being put in as required, at the various stations; a switch-box was provided moving on hinges, and presenting a circular opening through it, continuous with the tube, so that there was no interruption to the forward motion of the carrier; but on shifting the box, a receptacle with a cushioned end was presented, so that

the carrier and messages were arrested. The carrier being taken out, messages exchanged, and the carrier put into the through part of the switch-box, this was again returned to its normal position, when the carrier resumed its journey.

When the switch-box was moved so as to intercept the carrier, it will be evident that, without special provision, there would at once be a stop to the free circulation of the air, which is the specialty of this plan. To avoid this a bent tube was connected with the iron pipe on both sides of the switch-box, acting for the time as the main line of air circulation, whilst the box became as it were a blind siding.

In addition to the pneumatic tubes in London there are also numerous tubes in the provinces worked on the same system. The following statement shows their number and length :

Return Showing the Number of Pneumatic Tubes in Provincial Towns, and the time occupied in the Transmission of Messages, etc.

(The tubes marked * have been laid since the transfer.)

From.	From (Engine Station.)	To.	Indicated Horse Power of Engine.	Length of Tube.	Diameter of Tube.	Time occupied in Transmission.	
						Pressure.	Vacuum.
				Yards.	ins.	min. sec.	min. sec.
Liverpool *	General Post Office..	Exchange	17	791	2¾	0 45	0 57½
" *	" " ..	Water street	17	797	1½	1 5	....
" *	" " ..	County Galway	17	24	1½	0 4	....
Total length—yards.			....	1,612			
Manchester	York street	Ducrie Buildings	13	500	1½	0 29	0 30
"	"	Mocley street	13	300	1½	0 16	0 17
" *	"	Post Office	13	225	1¾	0 8½	0 9
"	"	Counter	13	17	1½	0 2	0 2
Total length—yards.			....	1,042			
Birmingham	Exchange Buildings.	New street, Ry. Station	3	140	1⅜	0 6⅘	....
" *	" "	Cannon street	3	240	1½	0 11	....
" *	" "	Post Office	3	318	1⅜	0 24	....
Total length—yards.			....	698			
Glasgow	General Post Office..	Royal Exchange	7	242	2¼	0 22	0 30
Total length—miles.			....	2 miles 74 yds.			

Between Telegraph street and the General Post Office, a distance of 852 yards, 2 tubes were laid side by side, making a length of 1,704 yards of piping. The communication was worked with the existing machinery, and found to answer very well ; and subsequently the tubes were extended to Temple Bar, a further distance of 1,333 yards, or 2,666 yards of piping, making the General Post Office an intermediate station.

In Mr. Scudamore's report on this subject, he remarks : "The double tube forms what may be called a pneumatic railway, with an up-line and a down-line, having their termini in Telegraph street

and at Temple Bar, and an intermediate station at the General Post Office. The up and down lines may be open throughout their entire length, or may be blocked by switch-boxes at the intermediate station. The terminal stations can send carriers through to each other without stopping at the intermediate station, or can send carriers to be stopped by the switch-box at the intermediate station, and the intermediate station when it knows a through carrier to be coming for one of the termini, can, if it happens to have any message of its own for that terminus, switch out the through carrier, insert its own messages, and send the carrier on again without any appreciable delay. The tube being of large size, the carriers are proportionately large, and each will hold about 50 messages.

"When pressure and vacuum are employed the distance between Telegraph street and Temple Bar is traversed in 3 min.; when vacuum only is employed 5 min. are required for the transmission.

"The tube is now working much within its power, and yet is doing work which fully occupied 6 wires and 12 clerks. If the extension to Charing Cross be successful, as there is every reason to suppose, the tube will take up with ease the work of 12 more clerks."

As there would be some difficulty in working the line under ordinary circumstances, it is arranged to work on the ordinary railway block system, with a special code for description of carriers. This plan has been found to answer very well; and the traffic is carried on without stoppage.

In Mr. Siemens' original system it was intended to work the tube, keeping up the circulation by means of a vacuum in front of the carrier, the rear of the tube being subject only to the ordinary pressure of the atmosphere. With the Post Office tube this transmission was found to be slow, and the experiment was tried of working by pressure as well as by vacuum, or the two combined; and the effect of this was to reduce the time from 5 to 3 min.

In addition to those stated in the foregoing table, three tubes have just been completed in Dublin, one of 1,530 yards and two of 700 yards each. So the total mileage of pneumatic tubes in the United Kingdom, will be—

London	3	694	Clarke's System.
"	2	850	Siemens' "
Dublin	1	1,170	Clarke's "
Liverpool		1,612	
Manchester		1,042	
Birmingham		698	
Glasgow		242	
Total length	9	1,028	

Referring to the information given as regards speed of transmission, it will be seen that a greater speed is obtained with the larger size pipe. Liverpool gives a striking example of this, for with 2 pipes of nearly the same length the time of transmission in the smaller pipe is nearly half as long again as in the larger pipe. It has been found in practice the best plan to use the 1½-in. pipe for short distances, but for distances over 500 yards it is most advisable to use the 2½-in. pipe. The speed of transmission through different lengths of pipe is found to vary inversely as the squares of the distances, *i. e.*, in straight pipe. In practice it is found experimentally that the various curves and inclines affect the speed materially, and therefore the law given does not work out correct in practice, but the actual result comes between the inverse proportion of the length and that of the squares of the length.

The tubes are very enduring, as repairs hardly appear to be required, and the number of extensions already made by the Post Office, and the fact that others are contemplated, is sufficient evidence of the estimation in which the pneumatic system is held, as regards its great utility and value.

A New Jersey decision makes railroad companies responsible for local improvements, paving, grading, etc., in cities, notwithstanding the usual stipulation of railroad charters that the tax of ½ of 1 per cent. per annum paid into the State Treasury should be in lieu of all other assessments to be imposed upon them.

A movement is on foot for erecting a bridge over the river Blyth, and with full concurrence of the Blyth Harbor and Dock Committee.

TRANSMISSION OF POWER BY WIRE ROPES.*

If an account of the transmission of power by wire ropes would be of sufficient interest to your many friends and patrons, you are at liberty to appropriate the following general statement to the columns of your valuable journal, when not required for more interesting, or, perhaps, instructive matter.

Immediately preceding my recent hurried departure for the Continent, my attention was directed by my friend, Col. J. Albert Munroe, Civil Engineer, of Providence, R. I., to the economy in the development of water (and other) power by a system of its transmission, successfully in operation in Germany, but as yet believed to be without adoption, *if known*, in the United States. The subject was one of no ordinary interest to me, as Col. Munroe had been recently employed in making plans and estimates for the development of a very valuable but unimproved water power and estate, which I have for several years hoped to see occupied and fully developed by an association of capitalists having the pecuniary ability necessary for that purpose, and beyond my own. My friend's action was valuably assisted by Col. W. A. Roebling, Civil Engineer, of Brooklyn, N. Y., who not only informed him of the pamphlet publications upon this subject, but of the particular localities where the plan was in successful operation. One of these being at Hohemark, near these springs, I visited the place last Wednesday (June 28), and premising the statement of what I saw by stating that my observations were made in a heavy rain storm, and a long walk in mud and wet, which must account for any discrepancies of fact in measurements, the results obtained were these.

There is a very large cotton yarn manufactory, employing about 450 hands, that is driven by steam and water power combined, having 150-horse power from the former and 100 from the latter. The former is from a double-acting engine, having 1 cylinder of 3 ft. diameter and 5 ft. stroke, the other cylinder of 2 ft. diameter and 4 ft. stroke, driving a large 12 ft. gear, and making, as per register, in the 12 hours' labor the day previous, 84,035 revolutions. The valves of the large cylinder were about 5 in. opening, and operated by the ordinary eccentric on the crank shaft. I observed none of the more modern appliances of cut-offs, which might have arisen from a more critical knowledge being necessary on my part. The engine was made by Benj. Hick & Son, of Bolton, England, horizontal, and of excellent finish and operation. There were 3 tubular boilers, whose capacity I did not learn. Upon the ordinary crank shaft of the engine were bevelled wheels, receiving power from 2 Turbine wheels, of perhaps 3 ft. diameter.

Upon the outside of the wheel-house a large 12 or more feet iron wheel was revolving at the rate of 140 revolutions per minute, receiving its power from a similar wheel by means of a wire rope $\frac{3}{4}$ in. in diameter. There are 8 of these wheels, with 2 grooves in each (for receiving and transmitting power), 400 ft. apart, upon triangu'ar iron frames, supported by strong stone under-structure and with 2 *spare* wire ropes for each 2 wheels, arranged for immediate application in case of injury to the 1 or 2 operating. The power thus transmitted is from a third Turbine, over 1,200 ft. from the mill, in a separate wheel-house, and connected also with the mill by telegraph wires, the wheel or gate tender living in an upper story of the small wheel-house, to receive or transmit information as necessary. The water supply to this third Turbine is brought from the Taunus Mountains, over a mile distant, in boiler iron tubes 18 in. in diameter. The tubes terminate at the mountain in a reservoir of cement 18 ft. square and 20 ft. in depth. The overflow of surplus water from the reservoir is conducted by means of an ordinary aqueduct to the 2 Turbines at the mill. One peculiarity in the application of the water to the Turbines arrested my attention. It *appeared* to be *horizontal* in direction, and not vertical, as I observed no cylinder in which the wheels were placed (it is true the submersion may have prevented their being seen), but the wheel-houses were square, and the water was thrown with great violence against the sides. The fall from the mountain reservoir to the mill is 400 ft. (through the iron tubes

* By ELISHA DYER, in a letter to "American Railway Times."

and aqueducts), and is explanatory of the force applied to the Turbines. The wire ropes are in coils of 250 metres in length (equal to very nearly 850 ft.), and cost from 140 to 150 florins per rope ($55 to $60) at the manufactory. The ordinary wear of a rope is from 6 to 8 weeks, except in imperfect manufacture or inferior material, where the liability of breakage is of course greater.

I think there can be but little question, from what I saw, of the expediency of a thorough examination of this subject in the United States. I am aware of the very great difference in cost of labor and material with us, from the continent of Europe. But taking into consideration the great expense of bulkheads to the canals or trenches from the dam, the still greater cost and difficulty of the excavation and construction of wheel pits and houses, I can but think there may be a less disparity in cost than would at first seem to exist. The superior advantages in selecting building sites, where material for building, security of foundation, and less of liability to damage by freshets, can be considered are very important arguments for the adoption of this mode of creating and transmitting power. The bulkhead and gates of an ordinary water power could as easily be constructed for the occupancy and use of the Turbine, or more ordinary breast and bucket wheels, as at present. The race-way might require additional length and depth to secure the advantages of the head and fall. But this part of the development of water power is generally of less cost than any other, requiring but little masonry or cement work after leaving the wheel pit. The different applications of this power, in different directions of different quantities, the avoiding of bevel gears, change of motion, and the numberless suggestions and advantages its adoption would produce, make it appear strange that, with all the scientific progress of our mechanic arts, and economical appliances in generating power by steam or water, for 20 years this principle has been so successfully applied in Germany, with full published particulars of construction and use, and yet, except in the most minor manner and detail, it is comparatively unknown to us.

Before leaving this imperfect account of Hohemark, I should add, as of interest to the different advocates of free duties and a protective tariff, that the children employed in the mill, from 14 to 16 years of age, receive 32 kreutzers per day of 12 hours' labor (equal to 22 cents); from 16 to 18, 34 kreutzers; adults, men, 1 florin, (60 kreutzers—40 cents); and the spinners, 1 florin, 12 kreutzers per day. The production of the mill is 4,000 to 5,000 lbs. of yarn daily. American and Indian cottons are used, but the former is decidedly preferred on account of superiority of strength and fineness of fibre. The association or company hold the property in shares, and its pecuniary results indicate energy, intelligence, and success. I may further add that the revolutions of the steam engine were distinctly and accurately indicated by a very simple indicator made by Schaeffer & Budenberg, Buckau-Magdeburg, No. 3,588. The register for June 23 (12½ hours' operation), 92,801; June 24 (12 hours), 80,348; 26th, 83,624; and 27th, 84,035.

Upon my table, open before me as I write, is the very interesting pamphlet and drawings of Prof. J. H. Kronauer upon the transmission of this same kind of power at the falls of the Rhine at Schaffhausen, and which is published by J. Winster & Co., Winterthur, 1870.

On the left bank of the river at Schaffhausen advantage has been taken of the rapids, and a dam being constructed across them somewhat of a triangular form, with the apex toward its downward flow, a Turbine wheel and house has been erected and placed. From this the power is transmitted to the right bank, up and across the river, as necessity or inclination required; down the river, and in fact it seemed as though fancy had merely to suggest a location, and, fairy like, a wheel was there revolving, as if by magic power, unseen. Corn mills, machine shops, turning shops, and any branch of industry requiring power, receives and transmits its incessant motion, *away* from the river, as if performing the most neighborly acts of kindness, ignorant of the source of its benefactions as well as of their value. Over 300 horse-power is now rented by the company developing it, and a large revenue is therefore remunerating them for their enterprise and energy. How much more can be rented I know not. But the force and quantity of the Rhine at Schaffhausen would seem as though

"the half had not been told." The origin of the enterprise, as the pamphlet states, was the energetic action of Heinrich Moser, of Charlottenfels, who formed the company, known in Germany as the Schaffhausen Water Works Association. The pamphlet of Professor Kronauer is full of details and plans so minute as to be a sufficient guide for the construction of similar works, comprehending even the tools employed.

Col. Munroe's second note also refers me to the efforts of the Swiss brothers, Hirn, in this same matter, the locality, however, not mentioned; also to a description of the same by Professor F. Realeaux, in his "Constructeur," but no date or place of its publication is given. At the Paris Exposition of 1867 this power was transmitted 300 ft. by means of a $\frac{1}{2}$-in. wire-rope. Fearing, Mr. Editor, my personal interest may have already trespassed upon your own and readers' patience, I retire from its further consideration, amply repaid if my efforts have your own and friends' commendation.

PLASTER OF PARIS MANUFACTURE.

From "Engineering."

The quarrying of gypsum and the manufacture of plaster are important industries in Paris, and we have recently taken the opportunity of visiting one of the establishments of this kind, the best arranged, that of M. Morel, at Montreuil. The plaster of paris, or gypsum, consists, as is well known, of hydrated sulphate of lime. The water being removed by roasting, the stone is ground into powder. When this is afterwards mixed with water, it combines itself again, and forms a solid mass, which is employed in an infinite variety of ways. The abundance of gypsum at Montmartre, Pantin, Menilmontant, Belleville, Charonne, Montreuil, etc., all close to Paris, even within the city limits; the good quality of, and the large demand for the plaster, and the ease with which it is employed, have caused the development of this great industry in the capital. The plaster of paris has a European, and even a still more extended reputation. It is employed everywhere, and is put to the most varied uses. It is moulded into hollow bricks and tubular blocks, in building up partitions and walls, for paving slabs, and for smoke conduits to chimneys. One sees even in the neighborhood of the quarries, houses of 3 and 4 stories, which are built in moulded stones of plaster, or made in plaster in such a manner that they form a monolith.

The bed of gypsum worked at Pantin is horizontal; it has a thickness of 37 ft. 2 in. There is also a small bed adjacent, and of little thickness, but this is not quarried as a rule. The gypsum of this bed is almost entirely crystallized, and there are found there, in abundance, those beautiful specimens called *fers de lance*, on account of their form. These fragments split with ease into thin transparent leaves, and when the apparent limit of divisibility has been formed with the blade of a knife, if one takes one of the leaves, which has less than $\frac{1}{80}$ in. of thickness, and heats it, it exfoliates into more than 20 films, as the water it contains is heated and disengages itself in steam.

The bed of gypsum that is excavated is covered by some 40 ft. of earth, consisting of calcareous deposits and marl and clay. It is excavated, for the most part, by subterranean galleries, but it is sometimes found more economical to work from the surface, in spite of the great thickness of superincumbent earth, because there are numerous situations where the excavated material employed to fill elsewhere, can be made a source of revenue, while the limestone can be sold to make lime, and the clay to make earthenware or bricks.

It is thus that the quarry of Eprisette, worked at first in galleries by M. Morel, is changed at the present time into open excavation.

The gypsum is extracted by blasting. Holes are pierced in the rock, which, for the most part, is sufficiently soft for a workman to drive, in less than an hour, a hole from 4 ft. 6 in. to 6 ft. deep and 2 ft. in diameter. After a blast, the rock is struck with crowbars, which divides it into blocks from 30 to 40 metres cube, advantage being taken of the numerous faults in the material, which the workmen

learn to recognize at a glance, and which they call "*maillances.*" A heavy blow, or the introduction of a pick, at the right spot, divides easily the largest blocks into convenient fragments.

These fragments are loaded upon trolleys, which follow the face of the gallery or cutting on tramways, and which lead up to the 8 furnaces composing the factory. These kilns, or furnaces, are of the simplest form. They consist of an end wall 15 ft. long, and of 2 side walls of the same length. The 3 walls are also 15 ft. high, and the square hearth that they surround carries perpendicularly to the end wall 5 gratings, through which passes the air necessary for combustion. On the ground, the largest blocks of gypsum are arranged, in such a manner as to construct above these gratings arches sufficiently high to receive the fuel for burning the material. The spaces intervening are filled up with other fragments of rock, more of which is added from above, so that the height of the mass is raised. When the greatest height conveniently attainable by hand is reached, the charging of the kiln is continued from trolleys brought upon inclined planes, which are also supplied with rails. This is carried on until the height of the charge is equal to that of the walls of the kiln. All the interstices are then carefully packed with small fragments of the stone, and the front of the furnace, which is raised by a low wall, receives a movable cover of plate iron intended to prevent the loss of heat by radiation, and to retain such morsels of stone as become detached during the operation of baking; the joints in the front of the k ln are luted.

Everything being then prepared, fagots are placed within the arches and lighted, and when the embers are in full glow and the arches half empty, they are charged with briquettes of artificial fuel, and the fire is so managed by regulating the access of air, that the baking of the mass is effected equally throughout without any extremes of excessive or imperfect burning. The operation is complete in 24 hours.

The employment of briquettes is one of the improvements introduced by M. Morel into his establishment. The baking was generally done with wood, and the substitution of coal has effected a saving of $\frac{3}{4}$ of the total quantity produced. There is but a comparatively small loss of heat in this apparatus, so simple and apparently so primitive. In calculating the calorific power of the quantity of fuel consumed, and the amount of heat necessary to evaporate all the water contained in the gypsum, it is found that he utilizes $\frac{1}{2}$ of the available heat, which is certainly a satisfactory result, considering all the various losses inseparable from an identical enterprise.

After the calcination is complete, the furnace is allowed to cool, and the burnt gypsum is again loaded into wagons and carried off on the tramway to the grinding mills. This part of the manufacture consists of 2 parts. There are the mill stones in cast iron or stone, banded with rings of iron, and turning in a circular trough with a grated bottom. The calcined stone is fed into the mill, and those parts which are ground down extremely fine pass through its gratings. The rest is removed by a suitable mechanical appliance for grinding.

One of the mills carries a most ingenious arrangement for screening the fine powder. Below the grate there is a strainer in the form of a truncated cone. Of the powder which falls upon this strainer through the base of the annular grate, a part passes through the meshes and escapes through the lower part of the apparatus, the rest slides on the conical strainer falling on a table at the bottom, and is constantly lifted by a chain and replaced on the table of the mill. After the powder is sufficiently ground, it is conveyed below into a storehouse where it is placed in bags. The mills are driven by a 12-horse steam engine.

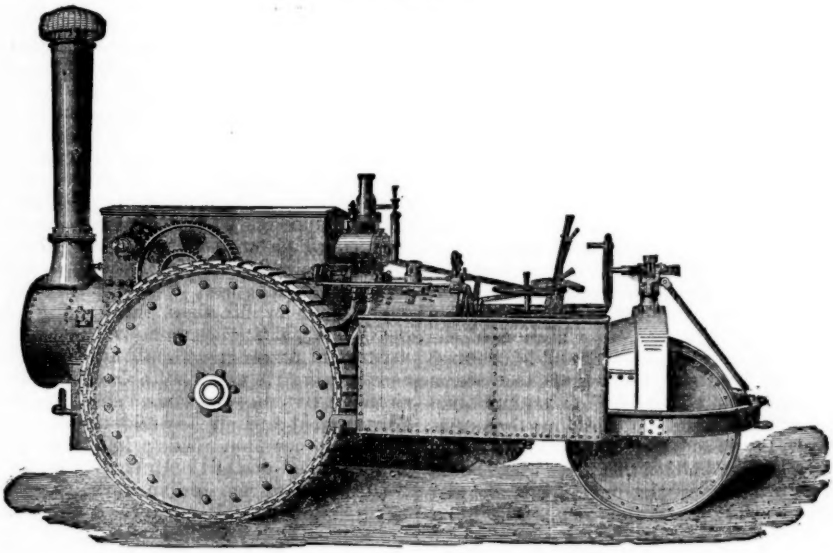
The whole of this establishment is ably arranged and managed, from the quarries to the plaster depot, and the working out of all the practical details does honor to the able proprietor who created them, and who still works daily to improve them.

Earl Granville believes there is no intention of continuing the Thames Embankment on the south side of the river.

Specimens of coal and gold quartz, from the neighborhood of Bangalore, have been favorably reported on by Dr. Hunter.

STEAM ON COMMON ROADS.

From "The Engineer."



We give, in the above engraving, an illustration of that which is, in our opinion, one of the best designed locomotives yet constructed. The engine is nominally of 12-horse power, and has been made for the Turkish Government.

The engine is carried on 4 wheels, the 2 drivers being fitted with Thomson tires. They are 6 ft. 1½ in. high, and the rubber tires are 14 in. wide. The steering wheels are of iron, with a raised central tire rib. They are 4 ft. 2 in. in diameter, and fixed on a short axle, so that they are very close together. A single vertical pin rises from the axle and is surrounded by a strong helical steel spring. The tires of these wheels are 7¼ in. wide.

The boiler is of the locomotive type, the fire-door being at the side, next the reader, and not shown in our illustration. The foot-plate is convenient and the coal space very large. The horizontal wheel shown actuates a worm wheel, which will be seen under the foot-plate. On the axis of the worm wheel is a pinion, which gears in a gun-metal rack or quadrant bolted to the boiler; by the use of this wheel the boiler can always be kept level on inclines. The device is not new, having been used by Mr. Smith, of Coven, many years ago, but it is very cleverly carried into practice. The fire-box has 26 sq. ft. of heating surface, and the tubes 205 ft.; total, 231 sq. ft. We need hardly add that the boiler produces an abundance of steam.

The cylinders are 7½ ft. in diameter and 10 in. stroke. The crank shaft is of the best forged scrap iron, and all the bearings are of wrought iron, with long brasses. The eccentrics are turned out of the solid. The engine is double-geared on both sides, the wheels and pinions being all of McHaffie's malleable iron. The speeds are 4 and 8 miles per hour, and the total weight of the engine is 8 tons, of which the larger portion by far is carried on the drivers. The tank under the boiler holds about 250 gals.

The workmanship throughout is thoroughly good. Our illustration is taken from a photograph, and shows the engine unlagged and unpainted as it came into the yard fresh from the works, only having been finished a few hours before it was sent off by rail. It is to be regretted that it was not in time for the competition at Wolverhampton. It would certainly have taken a prominent place, and will doubtless give perfect satisfaction to its owners.

A Parliamentary paper recently issued consists of 3 copies of petitions received at the Board of Trade, with reference to the use of steam engines or locomotives on the common roads, and a memorandum on the subject by Captain Tyler. Two of the petitions from Ireland being identical in wording, we only reproduce one, a memorial by the magistrates, etc., of the county Kerry. The other petition emanates from the grand jury of the same county. The third comes from Leith. It may be as well to explain that some time since a private bill was passed for the construction of a tramroad on a public road in Kerry, and it was at first contem-

plated to work this road with horses ; it was subsequently very properly decided that it would be better to work it with small locomotives on traction engines, weighing about 7 tons, which, availing themselves of the tramway as much as possible, would yet be able to quit it for the ordinary road when need to do so came, so that the steam train could either get out of the way of ordinary vehicles, or take its wagons right up to the farmer's door. As to the recent progress of this scheme we are unable to speak ; but we have no doubt that the desire to use steam instead of horse power led to the preparation of the petitions in question. To whatever cause they are due, however, there can be no doubt that they express the wishes of a very large section of the community. Whether the old-fashioned people who still hold that the steam engine should find no place on our highways, wish it or not, the time has come when the traction engine must be recognized and admitted to a place with horses. The prejudice of the quadruped must give way to the interests of men. The horse must be educated to like the road steamer, or at all events to regard it with indifference; and far less difficulty will be incurred in imparting this education than is commonly supposed. Steam on our highways we must and shall have, and the sooner horses and their owners reconcile themselves to this fact the better for both.

Captain Tyler has taken a very sensible view of the matter, and most of his recommendations we cordially endorse. The rules which at present weigh most heavily on makers and users of traction engines are those which limit the speed to 2 miles an hour in towns and 4 miles an hour in the country, and further insist on the presence of a man with a red flag, at a distance of not less than 60 yards in front of the locomotive. The limitation of speed was introduced into the bill on the recommendation of a single eminent firm building traction engines, and was intended to get rid of certain nuisances in the shape of so called "pleasure" locomotives, for the most part hideous in design, noisy in action, and dangerous to their owners and every one else. These engines were run without caution at from 10 to 15 miles an hour, and they drew so much odium and contempt on the road steamer, and so strengthened the prejudice against it, that it was not improbable at one time that the use of traction engines in this country, then in their infancy, would be wholly prohibited. But this excuse for keeping down speed by legal enactment has completely passed away ; the legislation of the past 7 years or so has served its turn, and must give way to something better. We know that some makers of road locomotives still hold that 4 miles an hour is a sufficiently high speed under any circumstances, simply because they have hitherto confined themselves to the construction of engines which will go no faster ; their engines are admirable for hauling heavy loads, but the steam engine has a far wider field to fill than the hauling of heavy loads at 4 miles an hour. The conveyance of passengers should prove quite as remunerative under suitable conditions as the conveyance of goods. The Indian Government are already adopting steam trains on common roads ; in Egypt, in America, and on the Continent of Europe, the example of the Indian authorities is being followed, and our own country is not yet so fully supplied with the means of intercommunication that the steam omnibus should be considered as a thing unnecessary and to be legislated against. The Act restricting speed has done a great deal to retard the progress of mechanical science in the construction of road steamers, and in no way has it acted more prejudicially than in removing all temptation in the way of engineers to construct engines which shall be silent, sightly, and fast. It matters nothing, under existing circumstances, whether an engine is, or is not, a huge, ugly, lumbering piece of mechanism, simply because no responsibility worth the name attaches to the maker or user under the existing *régime;* so long as he has hired his red flag man, and his head light, and his slow speed, he can make as much noise with his engine, and the engine itself may be as fearful in its aspect, as he pleases. He may obstruct thoroughfares and frighten horses to his heart's content. But let Captain Tyler's recommendation be acted on, and let it once for all be decided that the user of an engine is to be responsible in the sense that any user of an ordinary vehicle is now responsible for damage done, and we shall find that much care will be taken to make traction engines inoffensive to

horses and men, and a stimulus will be at once imparted to engineers to produce machines much superior to any they have yet turned out of our workshops.

As regards the operation of the existing Act again, it is well known to all users of traction engines that it is practically *nil*. The man with the red flag never precedes the engine under ordinary circumstances; he carries his flag, and he gets carried himself on the engine or in one of the wagons, far more quickly and pleasantly than he can walk. He can always see a carriage or other vehicle far enough ahead to permit him to jump down and run his 60 yards ahead before it comes up to the engine. In towns the flag might be useful, if it were not superfluous. The noise made by the engine, and the rush of a crowd of dirty little boys, is always sufficient notice of the approach of a steam train through a town. The engine and the shouting can always be heard before the red flag can be seen. And besides, in 9 cases out of 10, if a horse manifests alarm, the man with the red flag rushes up to his head waving that objectionable bit of scarlet in his face in a way to startle any horse of average intellect. The engine he might get over, but the red flag and the engine combined we have always found too much for the strongest equine nerves, and in our own practice we have always insisted on the suppression of the flag the moment a timorous horse appeared on the road, and with the very happiest results. As regards speed, again, it does not appear to have struck our legislators that a traction engine moving at but 4 miles an hour, is certain to be passed from behind as often as it is passed from the front, and we have invariably found more trouble from vehicles coming up in the rear than from those approaching in front. Over and over again we have heard the words, "I do wish you would get on faster and keep out of people's way." To be consistent, the Legislature should have insisted on the presence of a man with a red flag behind the train as well as one in front. We have no hesitation in saying that the moment engines are permitted to proceed at 7 or 8 miles an hour, and do it, the chances of accident and the risk of obstruction to ordinary traffic will be reduced by or e half.

The direction which legislation should take has been very properly laid down by Captain Tyler; but we must take exception to his first proposition. It will be matter for regret if Parliament, acting on his recommendation, should insist on the adoption of the Le Chatellier brake, or, indeed, any other patented invention. It is perfectly well known to the drivers of traction engines that they can keep their engines in complete control with the ordinary reversing lever. If anything further is wanted it is supplied by the simple hoop brake, such as is used by Messrs. Aveling & Porter, of Rochester. The Chatellier brake would not provide for such a contingency as the fracture of a chain or the stripping of gear. All that it can do is done already, as we have said, by the ordinary link motion. On one point Captain Tyler is thoroughly right; every traction engine should be worked under license from the Board of Trade. Under this restriction it would have been impossible for any one to have put on the road such an engine as that sent to Wolverhampton by a Shrewsbury firm. This engine ran away down a hill and killed the steersman almost on the spot. It will scarcely be credited, but it is no less true, that there were no brakes, and, in the proper sense of the word, no reversing gear. The engine must be stopped to shift the single eccentric round on the shaft. On its way to Wolverhampton this engine had to descend a hill; steam was shut off, but it acquired an increasing velocity nevertheless. The driver, in his evidence before the coroner's jury, stated that he attempted to stop it with "a screw jack against the wheel;" then the pitch chain—such a chain—came off, the engine turned into the ditch, and the poor steersman in front jumping off, or being knocked off, fell and was run over by the wagon following the engine. Under a proper system of examination and license such a casualty would not have occurred from such a cause.

We are pleased to find the manifestation in practice of a growing tendency on the part of engineers to make their engines more sightly and less likely to annoy horses than hitherto. Mr. Thomson and those working with him box up their gearing out of sight. Messrs. J. Fowler & Co. have adopted a capital remedy for the noise of the exhaust in the chimney, which is thoroughly efficient, and Messrs.

Burrell, of Thetford, have introduced a design in the shape of an engine intended for the Turkish Government (see illustration), which appears to us to be a decided step in the right direction. Some of the road steamers formerly built by Mr. Tuxford, have never been excelled in an æsthetic sense, whatever may have been their merits or demerits in other respects. With improved legislation, and the increased demand sure to follow for common road locomotives, it appears to be certain that improvements will be made in their construction which will speedily eliminate many of the causes of objection now brought against them.

ON STYLE IN ARCHITECTURE.

From "The Builder."

We offered, in a recent number, some remarks as to the meaning and value of what is called expression in architecture; one of those qualities which are more easily perceived than defined, but the importance of which is not to be on that account underrated. As we laid stress at the time on the existence of a marked distinction between *expression* and *style* in architecture, a few remarks as to the nature and distinctive characteristics of this latter quality can hardly be said to be *àpropos de rien*. As in the case of a good many terms in common use among us with regard to art, we have, in speaking of style, to clear away a certain amount of ambiguity of meaning before we can even arrive at a clear understanding as to what we are talking about. Style is a word very loosely used even in regard to architecture; still more so in its application in connection with other branches of art. We recognize, in a broad sense, various "styles" of the art of painting; but we speak also of the "style" of a particular artist in a much narrower sense, and with reference generally to distinctive peculiarities of manner. In speaking of literature, the word is used exclusively in this narrower sense, as indicating not the school of thought to which a writer belongs, but the distinctive characteristics of his mode of expression. The word as used in these two relations means in fact very much the same as we mean by "character" or "manner" in architecture. But in regard to the latter art we commonly use the word "style" in a wider sense, as the distinguishing name for differences between schools rather than between individual architects. We include under the general title of the "Gothic style," buildings in which the manner, or what we may term the handwriting, of the various designers is as distinct as possible. We formerly applied the term to all buildings with pointed arches; we have more recently perceived that what made Gothic a style lay deeper than that, and the meaning of the term has somewhat extended, to the length of becoming perhaps rather too vague. But inasmuch as we all recognize style as something distinct from expression, and are constantly making use of the word with more or less precision of meaning, we may contribute to a rather more definite idea on the subject by considering for a moment what "style" is,—what makes a style in architecture as distinct from mere character or expression.

There are necessary conditions for fulfilling the idea of style which are not very easily definable, though they are easily apprehended in a general way by the eye and mind, and would almost naturally occur to any one giving a thought to the subject,—we mean such things as the harmony and mutual fitness and suitability of the different decorative features in a building. We feel instinctively when this suitability does or does not exist. We should at once feel a sense of discord and unfitness in seeing such an ornament as the square Greek fret placed on a building in conjunction with or in proximity to a band of carved foliage in the Gothic style; but looking at the two features superficially, it is not so easy to point out wherein they are so discordant, what special qualities render their joint employment an anomaly. To arrive at this we must come to a broader generalization; we must look, not merely at the ornament, but at its relation to the whole structure and to the principles on which the latter is put together.

If we ascend from ornamental detail to larger portions of the structure, we feel equally the incongruity that would result, for instance, from placing a pointed Gothic arch between two bays and lintels from a Greek temple, or merely springing a Gothic arch, with the usual mouldings and chamfers, from a Classic column, although the column would carry it just as well, structurally, as would the orthodox clustered pier. It might be urged that the anomaly in this and the former case was merely the result of long association of ideas. Perhaps we need hardly say that we do not admit this. Our opinion is, that architectural style, properly so called, consists mainly in unity of construction and constructive expression carried out, not only in the main structural features, but imitated and repeated in a lesser degree by the smaller decorative features; which latter, however, in proportion as they recede from structure and become purely decorative, in that proportion escape more or less from this structural influence and come under the regulation of another artistic law which we shall refer to.

As to structural unity of principle as an element of style, that has been several times insisted on as a condition by architectural critics. So far as the main constructive portions of a building are concerned, the employment, in a building of any size or architectural importance, of *one* form of construction, trabeated, arcuated, domical, whatever it be, is not a new principle, in theory at least, and is practically illustrated in most of the great historical monuments of architecture. But the formation of a consistent architectural style requires also that the main motive of the construction be carried out and exemplified in the detail of the building, a point which has not been so clearly recognized. This may be, indeed must be, done in two ways,—in regard to the main lines formed by the constructive portions of the building, and in regard also to the material used, and the method of treating it. In the Greek Doric style we see both requirement carried out nearly in perfection. Nearly the whole of the ornament (the sculpture is an accessory, not an architectural ornament) repeats, in its squareness, hardness, and rigidity of line, the square, heavy form of the pillar-and-beam construction. It is only when we get to the small finials or acroteria on the apse and spring of the pediment that we find any flowing lines, and those are arranged with a certain stiffness and precision to harmonize with the character of the whole building. Anything less rigidly conventionalized would be felt to be out of place at once. So, of course, with the Gothic, where every one knows how, in the full development of the style, the pointed arch is regularly carried out into even the smallest details; and even where the arch does not appear, the distinctive feature of the *point* is seldom lost sight of, and gives a crispness and sparkle to the smaller details closely allied to the treatment of the whole edifice. In the Saracenic style, again, the light form of the bulging and pointed dome gives, as it were, a license to the wild and elegant luxuriousness of ornament which characterizes the details of the style, where again not only is the appearance of lightness and pliability of material kept up in the details, but even the marked characteristic of the bulged dome, of the arch returned inward past its springing line, re-appears in the horse-shoe arches and sub-arches which abound in its fanciful arcades and wall-decorations. We are glancing here at the relation between detail and structure in regard to mere line and form; we must look at it, however, as hinted just now, in regard to treatment of material and relation of design and detail to the material. This establishes a relation between structure and detail in regard to some classes of detail, which, if we restricted our attention to mere outline, might seem to escape from this law. Such things, we mean, as sections of mouldings, plans of points of support, etc. What is it which really makes the incongruity in the case we supposed just now, of a Gothic arch springing from a Classic column? It is mainly the contrast between the deep, heavy mouldings and chamfers of the arch, and the shallow, delicate flutings of the column. We are here again brought round to constructive unity of design; for in every true and naturally developed style the mouldings and the surface treatment are the result of the consideration of the nature of the material. Greek architecture is essentially a marble style, Gothic architecture a stone style; a distinction which even now is scarcely appreciated,

but which, if it had been suspected 50 or 60 years ago, would have saved us a host of now meagre, desolate-looking, starved, would-be Greek erections, conceived and built in the vain idea of achieving in a comparatively dull, soft, and coarse material what could really only be effected in the bright, fine, hard marble in which the style originally rose into life. Deep sinkings, rounds, and hollows have no place in marble; they not only involve ruinous labor and expense, but lose the opportunity of showing the material in its most beautiful and perfect use, as capable of receiving and retaining the most delicate curves and contours, and the sharpest edges, and of preserving the effect of ornament more delicate than could be executed in any less hard and durable material. In dealing with stone, on the other hand the Mediæval architects felt that they had under their hands a coarse granular material, incapable (especially when exposed to the weather) of retaining a sharp arris or a delicate surface ornament; and they worked it accordingly into deep hollows, and took off by chamfering the edges which must soon have chamfered themselves. Marble and granite and such materials have no affinity with these expedients—a fact which is felt intuitively by modern masons; for who ever saw a polished granite pilaster with the arris chamfered off? We know better, even in the present day, than to despoil the material of the hard, sharp edge, which is one of its best characteristics. And viewing the relation between material and design in this light, do we not fairly establish the structural origin of style, even in regard to the sections of mouldings, when we look at these as taking their form and character from the nature and quality of the material, which in fact was the most important influence in determining the general structural design itself? We think so little of the nature of our material in these days; we are so apt to treat it at random in some preconceived manner, instead of in the manner best suited to "bring it to an excellent work," that we scarcely realize the intimate connection subsisting, in all unsophisticated and unforced architectural styles, between material and design. The recognition of this would go far to give something more like a consistent style to many of our modern buildings.

We alluded to another principle to which purely ornamental detail, in a consistent style, must bend, in proportion as it escapes from the dominion of structural considerations and structural form. There are generally to be found, in buildings of all styles, small details which seem so purely arbitrary and ornamental, that they may appear to have little or no dependence on the general style or structure of the building which they decorate. But even such details are bound by this law, that they cannot approach nearer to nature, cannot leave the conventional form of strictly architectural design, except in a ratio strictly consistent with the degree of conventionality subsisting in the general design. Small details may approach nearer to natural forms than can be suffered in the larger features of a building; but they must not be allowed to transgress disproportionately far in that direction. A Doric temple, for instance, is in a highly conventional style of architecture, and accordingly even the lightest and most unfettered of its details must be kept within the most artificial limits, and not suffered to approach in any way near to the irregularity of nature. Imagine the effect of a Gothic pinnacle, with its budding crockets and flowering finial, on the apex of a Greek pediment, and our meaning here will be obvious. Such an object, in such a situation, would appear simply ragged. But the Gothic and Saracenic, and some other styles, approach much nearer, in their general treatment and outline, to the picturesque forms of nature, and accordingly these styles will admit of ornamental detail which in proportion approaches still nearer to, and even very closely imitates, the form of natural vegetation. And this is the true æsthetic reason for the incongruity of appearance which would be presented by the supposed juxtaposition of the Greek fret and Gothic foliated carving, alluded to at the commencement of our remarks. Independently of their variety of form and character, they would not accord with each other because they are, if we may so speak, on different planes of departure from natural form; the Greek being very far, indeed almost entirely, removed therefrom, while the Gothic approaches much closer to it. So we see in all genuine architectural styles, that the *principles* only of nature being followed in the main

design, the *facts* of nature are allowed to be approached by regular gradation as we descend from the whole to the parts, and the more so as we go from details, which are partly constructional, or closely bound up with construction, to those which are purely ornamental; provided always that even in these latter an approach to natural fact is only warranted in proportion to the nearness to or distance from nature of the main design; that when the latter is purely architectonic and conventional, only a distant approach to nature can be permitted even in small details, and that this must be in regular gradation; *i. e.*, we cannot permit any one class of detail to assume an undue approach to natural form, out of proportion to what is allowed in other details in the same style, unless it be openly avowed as an addition to, and not a part of, the architecture (as in high-class sculpture applied to architecture). With this reservation, everything which approaches disproportionately near to natural form is an excrescence and an impertinence, and will not be found in connection with any true and consistent style.

Comparing theory, then, with the facts presented to us in the monuments of what we all agree to consider as among the most perfect architectural styles of the world, we are led to the conclusion that architectural consistency of design, which we call *style*, depends in the first place on structural consistency, in the employment throughout a building of one main principle of construction applied equally to the main structure and to the smaller structural details; secondly, on the carrying out and repetition of the main lines and structural treatment of material in all the smaller parts of the building in which structure is not entirely lost in decoration; and thirdly, in the principle, which controls every portion down to the smallest decorative feature, of consistency of treatment in regard to imitation of nature, which provides that the same building shall not present to us features strictly conventional combined with others which approach nearly to the irregularity of natural form, except just in that fit and proportionate gradation from the architectonic to the natural which is allowable, and even desirable, as we descend from the structural whole to the decorative portions. And here, then, it is evident wherein *expression*, which we treated of a few weeks back, differs from *style*. The latter is concerned with the treatment and relation of the architectural features, which form the integral part of our design; expression is concerned with the proportion, the variety, the position in which we use these materials. They may be, in other words, a dozen buildings in the same style, all with equal purity of detail, and in which all the main facts of the detail are the same, but they may be arranged and grouped in so many different ways as to produce buildings with a dozen perfectly distinct expressions. That we should be led to such a conclusion from a logical process of examination, is a result which may be consoling to those who think we can have no originality of architectural design without the invention of what they term a "new style." Any style worth the name is capable, in competent hands, of almost infinite varieties of expression, if our definition of "expression" in our impression of May 6th be the correct one. There may be, we may add, buildings with a great deal of expression and character, though without purity of style; and purity and consistency of style and detail may occasionally be found almost entirely devoid of expression, except that kind of set expression of dead immobility which belongs to Egyptian sculpture. But the position of the two qualities is broadly this: Style deals with the principles on which we are to invent and combine our materials for architectural design; expression is the result obtained by the varied manner, proportion, and juxtaposition in which such materials are used in special cases and by special minds.

In all probability we shall not see a single national style invented and universally adopted, in this or any other civilized country, as the Pointed style was in the middle ages. Modern education has given such variety and extent to our sympathies, that it is scarcely possible that the whole nation and the whole architectural profession could be again found to tread, by one consent, in the same steps, architecturally. Progress in this direction points rather to the adoption and maturing of 2 and 3 or more separate types of style, each with its own varieties of expression. Such types will, we believe, only be consistent and satisfactory if they adhere to the principles which

have governed former true and consistent architectural styles, and which have been, we believe, in the main, as hinted at above. Not that we have the slightest idea of the possibility of any architect or body of architects theorizing a new style into existence, out of the depths of their internal consciousness, on these or any other principles. Architectural styles never have been, and never will be, made cut and dried in that way. But it does not by any means follow, we submit, that, therefore, the subject is not one of interest in itself, and worthy of thought and consideration, which may prove suggestive in one way or another.

PRACTICAL ELECTRICITY.

From "Engineering."

M. Ernest Saint-Edme, Examiner in Physics at the Conservatoire des Arts et Métiers, and Professor of Physical Sciences, has just published an interesting volume on the application of electricity to the mechanical arts, in the navy, and in the theatres. Naturally he studies the sources of electricity, the apparatus employed, and all the various practical applications.

Amongst the sources of electricity, those most employed are galvanic elements; there exist of these a great variety, and it is difficult to say in which the inventor's ability has been most exercised. They are divided into 2 classes: those of great intensity and short duration; those of small intensity and of long duration. Among the first we may mention the bichromate of potassium element. In one series of vessels containing a solution of the bichromate, and $\frac{1}{10}$ part of anhydrous sulphuric acid, there is placed the necessary pair of plates, each formed of a plate of zinc, and 2 plates of charcoal; these are lifted out of the acid when the current is not required. This element, which produces a current of great intensity, is especially used in the service of exploding mines, or in surgical operations. In constant current batteries, the efforts of investigators direct themselves towards the suppression of porous vessels, the resistance of which, considerable when they are put in action, is much increased by the action of saline and metallic crystals.

In the element of M. Callaud, sulphate of copper and acidulated water are placed in the same vessel, and superimpose themselves in the order of their density. This battery cannot be moved about, but once installed in a fixed position, it gives a current of a very constant intensity.

M. Minotti places in the same jar a disc of copper, then a layer of sulphate of copper in powder, then a bed of pure sand, supporting the zinc plate. When water is placed in the jar, the action of the element begins, and its intensity remains constant so long as the loss of water through evaporation is replaced.

The sulphate of mercury battery of M. Marié-Davy, used in the telegraph service during several years, has been abandoned, and a return has been made to the sulphate of copper battery, in non-porous jars. M. Grenet has for some time applied successfully to bell-ringing apparatus a sulphate of mercury battery with a non-porous vase.

In the Léclanché battery, the carbon is surrounded with a mixture of peroxide of magnesia and of graphite, and which contains a solution of chlorhydrate of ammonia. Although the official telegraph administration has not adopted this apparatus, it has, nevertheless, come into favor in a large number of applications.

M. Warren de la Rue employs couples formed of a zinc plate, and of chloride of silver, contained in flasks of hard rubber, filled with saline water, and hermetically sealed.

M. Gaiffe has applied a new battery to his electro-medical apparatus. Two couples are sufficient to obtain, during 24 hours, 50 times the force of one nitric acid element.

Electro-magnetic machinery has received extraordinary improvements since the first arrangements of Clarke or of Pixii. We may mention the Gaiffe machine, the Henley magneto-electric key, the Siemens magnetic coil, and the electro magnetic machines of M. Noillet, employed in France under the name of the Alliance machine, which is especially

applied in the production of the electric light.

The thermo-electric piles, which have remained much the same since 1821, do not enter into the industrial domains. M. Becquerel forms each element from a plate of sulphuret of copper and a plate of German silver, composed of copper, of zinc, and of nickel. The pile is heated by a gas jet. Thirty such elements suffice to decompose water, to heat a platinum wire to redness, and to excite an electro-magnet. Each element is equal to about a quarter of a Daniel's element. MM. Morre and Clamont replace the sulphuret of copper by sulphuret of lead, whose electro-motive force is greater, and gives to the battery a more favorable power for utilizing the heat. All the inventions, however, of this class seem to represent but little progress in the delicate question of transforming heat into electricity.

The dynamic condenser of M. Garton Planté is a curious and important invention. It permits, so to speak, of an accumulation of the powers of a battery of 2 or 3 elements, until a discharge equal to the force of 50 or 60 is obtained. In a jar made with lateral grooves are arranged vertically a series of parallel lead plates, very close to each other, and perfectly insulated. One series of pairs of plates are connected, and put into connection with one of the poles furnishing the current. The same is done with the other series. The jar is filled with acidulated water. The current of the battery decomposes the water gradually, accumulating hydrogen on one group of plates, and oxygen on the other. If the two groups of plates are put into communication, the oxygen and hydrogen combine afresh, and produce a current of great intensity. The action of the apparatus may thus be indefinitely maintained. This condenser is employed almost exclusively in surgery.

Many applications have been made of electricity as a motive power: it is employed for driving sewing machines, in spinning factories, in railway brakes, etc., but it is especially in the transmission of indications that this power finds its most useful application. It is employed to send from a distance the thermometrical and barometrical observations, to indicate the presence of gas or fire-damp in mines; in some German towns, and also at Menton, near Nice, it is used to avoid premature inhumation.

After a rapid review of overland, underground, and submarine telegraphs, M. Saint-Edme takes up the consideration of the practical application of electricity to the marine. The protection of ships' plates and armor has been made the subject of special study by M. Becquerel at the port of Toulon. He has determined the electro-motive force of the metals and thin alloys entering into the construction of ships' plates, as compared with that of zinc, and has learnt what extent of surface of iron or copper a plate of zinc of given dimensions can protect.

Of electric lamps, those of Foucault and of Serrin supplied by an electro-magnetic apparatus, are employed for night signals on board ship, and for illuminating light-houses. During the last war the principal French iron-clads and gunboats were furnished with electric lanterns. By the help of this light, entry into port by night was possible, as well as manœuvres in the dark amongst crowded shipping. The same lamps can also be employed under water for submarine exploration.

Torpedoes have, of course, become a most important element of coast and harbor defence. To explode them the induction coil, with the Brequet exploder, is often employed, in which a current is generated by removing suddenly from the magnet its soft iron armature. The explosion is produced by the help of the Ebner fuses, in which the spark strikes a mixture of chlorate of potassium, of sulphuret of antimony, and of charcoal, or by Abel fuses. By this apparatus explosions can be produced at distances of 200 or 300 miles.

In the theatres for several years electricity has been employed for the transmission of signals, to give the time to musicians placed out of sight of the musical conductor, and by the help of the apparatus of M. Dubosecq, to light up any given part of the stage. M. Saint-Edme gives some interesting details of this latter application. He describes the means for obtaining rainbows, lightning, and illuminated fountains. He describes, also, the employment of magnesium and other lights, and the production of spectral and phosphorescent phenomena.

Electricity gives very beautiful phosphoric effects well known in physics by the Geissler tubes. These are utilized in the theatres in a variety of forms; for example, they are employed in the illumination of diadems and other insignia, in transformation scenes, and in the imitation of fireworks. Thus each day the practical appplication of electricity is extending, and for further information we refer our readers to the book of M. Saint-Edme, from which we have compiled the foregoing facts, in preference to making a formal review of the work.

RANSOME'S STONE FOR CAISSONS.

From "The Builder."

The uses to which the silicious concrete stone, invented by Mr. Frederick Ransome, is applied, are already numerous and varied, but the limits of its capabilities have not yet been reached, it would appear.

In some mining districts, engine pits that are to be lined with ashlar are sunk by "travelling cribs." The crib consists of a strong cylinder of iron, chamfered on its under edge to the outside; the upper edge square, and broad enough, either in solid thickness or by flange, to give a full bed to the first course of ashlar, upon which others are superimposed, and the travelling crib sunk until the requisite depth is reached. The process by which the stone caissons will accomplish the same result is similar in some respects, but essentially different in others. The first section of the caisson, for instance, is shod with iron, and takes the duty of the travelling crib; for the rest there are no "courses" of ashlar, but a succession of cylinders, lowered one after another as the pioneer section descends, the joints tongued and easily made water-tight before the water-level is reached, in the case of all that follow those that have to be lowered, in the first instance, under the water-line.

It will be readily apparent that these caissons, provided that the material is of sufficient strength, are applicable to the construction of hydraulic works of various kinds. The cylinders having been lowered to the requisite depth, the process of filling with Portland cement concrete is sufficiently simple; and, inasmuch as the caissons may be lowered in any number, and according to any arrangement in relation to each other, piers, abutments, sea or embankment walls, of any required strength, may be constructed.

The application of Mr. Ransome's process to hydraulic construction has been suggested by Mr. J. W. Butler, of Willesden, by whom, in conjunction with Mr. Ransome, the stone caissons have been patented. One principal object of the patent is to provide a cheap and efficient substitute for stone for hydraulic works, and another to obviate the necessity for false works, coffer-dams and the like, and to secure a much less costly mode of construction than by iron cylinders and caissons.

The strength and quality of the material to be employed in the construction of these stone caissons is, of course, a consideration of essential importance. As regards its quality and power to resist certain influences, an important report has been made by Prof. Frankland, who has tested its comparative porosity, the action upon it by acid, and by boiling. The water absorbed by dry specimens he found as follows:—Bath stone, 1.57 per cent.; Caen, 9.86; Portland, 8.86; Ransome's patent, 6.53. Alteration in weight by immersion in 1 per cent. of acid: Bath, 1.28; Caen, 2.13; Portland, 1.60; Ransome's Patent, none. Loss by three applications of acid, and by boiling afterwards: Bath, 5.91; Caen, 11.73; Portland, 3.94; Ransome's, 0.63. Ransome's stone has also been subjected to the crucial test of being boiled and immediately transferred upon ice, without the slightest effect being produced. But its power to resist crushing weight is of greater importance than these tests. From a series of comparative experiments, it has been ascertained that granite has a power of resistance to crushing of from 8,000 lbs. to 12,000 lbs. per sq. in.; Portland stone, 2,630 lbs.; Bramley Fall, 5,120 lbs.; and Ransome's, 8,960 lbs.

MILITARY RAILWAY AND BRIDGE BUILDING.

From "The Chicago Railway Review."

The United States Military Railway organization was created by the necessities of the war for the Union. The territory over which our large armies operated was so extensive that they could only be fully supplied with the necessary subsistence for men and animals, and the material for war, by rail; and the field of operations was so continually changing, and the requirements of the service so varied, that it became necessary to have a complete organization prepared to move instantly wherever their services were wanted, and fully equipped and prepared to perform any kind of railway service from the building of a railway to operating it to its full capacity.

The first attempt made was to use soldiers for the Railway Corps, but this proved a failure. It was found that men could not be both good soldiers and mechanics; they either neglected one duty or the other; for no man could properly take care of and use both his arms and his tools. So the plan of employing soldiers in this service was abandoned, and in their stead a corps of civilians was organized, whose members were increased or diminished from time to time, as the exigencies of the service demanded. These men, of course, had some arms, and when occasion arose used them; but their main duty was railroading. This at times was attended with as great risk as any branch of the service; and many brave fellows sacrificed their lives for the cause as gallantly as any soldier who perished on the field of battle.

THE PERFECTED PLAN.

It was not until about Jan. 1, 1864, that all the military railways were placed under one head—Col. D. C. McCallum, who was stationed at Washington. About this time Gen. Sherman was put in command of the Military Division of the Mississippi, and the plans for his great Atlantic campaign, and his march to the sea, were being matured. The question of supplying his armies while conducting the Atlantic campaign was the great problem to be solved. Could the system of railways necessary for this purpose be opened up as rapidly as required, and maintained in running order? This new and untried problem was placed in the hands of Col. W. W. Wright to solve, who was appointed Chief Engineer of the military railways in the Military Division of the Mississippi—the territory under Gen. Sherman's command. How well he performed the part assigned him is best told in Gen. Sherman's report of the Atlantic campaign:

"I must bear full and liberal testimony to the energetic and successful management of our railways during the campaign. No matter when or where a break has been made, the repair train seemed on the spot, and the damage was repaired generally before I knew of the break. Bridges have been built with surprising rapidity, and the locomotive whistle was heard in our advanced camps almost before the echoes of the skirmish fire had ceased. Some of these bridges, the Oostanaula, the Etowah, and Chattahoochie, are firm, substantial structures, and were built in inconceivably short time, and almost out of material improvised on the spot.

"Col. W. W. Wright, who has charge of the construction and repairs, is not only a most skilful, but a wonderfully ingenious, industrious and zealous officer, and I can hardly do him justice."

Col. Wright's force of mechanics and laborers was called the "Construction Corps," and was organized into divisions of about 800 men each, composed of subdivisions and squads of men for every kind of railway work that might present. The number of these divisions was increased or diminished as the movements of the armies were extended or contracted—the average number being seven. Each division was constituted as follows:

	No. of Men.
Division Engineer	1
Assistant Engineer	1
Rodman	1
Clerk	1
Messengers	3
Total	6

Subdivision No. 1.

Supervisor of bridges and carpenter work	1
Clerk and Time-keeper	1
Commissary	1
Quartermaster	1
Surgeon	1
Hospital Steward	1
Foremen (one for each 50 men)	6
Sub-Foremen (one for each 10 men)	30

Mechanics and Laborers	300
Blacksmith and helper	2
Cooks	12
Total	356

Subdivision No. 2.

Supervisor of track	1
Clerk and Time-keeper	1
Commissary	1
Quartermaster	1
Surgeon	1
Hospital Steward	1
Foremen	6
Sub-Foremen	30
Mechanics and Laborers	300
Blacksmith and helper	2
Cooks	12
Total	356

Subdivision No. 3.

Supervisor of water stations	1
Foreman	1
Mechanics and Laborers	12
Cook	1
Total	15

Subdivision No. 4.

Supervisor of masonry	1
Foreman	1
Masons and helpers	10
Cook	1
Total	15

Subdivision No. 5.

Foreman of "Ox Brigade"	1
Ox drivers	18
Cook	1
Total	20

Train Crew.

Conductors	2
Brakemen	4
Enginemen	2
Firemen	2
Cook	1
Total	11
Grand Total	777

Track laying and bridge building being the principal work, subdivisions Nos. 1 and 2 comprised the main part of each division. When it was necessary the whole division was employed at any piece of work. This extended field of operations, and the rapid movements of the corps, made the transportation of wagons and mules for their use impossible, so the necessary hauling was mainly done by oxen taken from the droves of beef cattle accompanying the armies. When necessary these could be killed for food. The work of the Construction Corps was a "new departure" in railway construction, and it inaugurated the rapid work which has been so successfully accomplished on our Pacific railways. Many feats of this corps might be cited, but two will suffice for the present.

The bridge over the Chattahoochie River on the line of the Chattanooga & Atlanta R., 12 miles from Atlanta, was built and ready for the passage of trains in 4½ days. This structure was 780 ft. long and 90 ft. high. Nearly all the timber used in its construction was cut in the adjacent woods, and prepared within the time named, and the wreck of the old bridge (which had been burned), consisting of an immense mass of tangled wood and iron, had to be removed before the new one could be erected.

In October, 1864, Gen. Hood swung his army around to the rear of Sherman, who was at Atlanta, and destroyed 35 miles of the road leading to Chattanooga. The road was broken at several points, but there was one stretch of 25 miles in length where the track, bridges, water stations, and everything pertaining to the road was completely destroyed. This gap was rebuilt in 7½ days. All the bridge timbers and nearly all the cross-ties had to be cut, and most of the latter were carried by men to the road, as there were not sufficient teams for hauling. Most of the iron rails were brought from Nashville, over 200 miles distant, and the balance were obtained from roads in the hands of the enemy, where a force had to be sent out every day to fight for what was wanted.

The high price of railway iron in 1864, and the difficulty of obtaining the required amount for military roads as far south as Chattanooga, induced the building of a rolling mill at that point for the purpose of working up the large amount of damaged rails that had accumulated on the different roads which the enemy had broken from time to time. This mill was built by the Construction Corps, at a cost of $290,000, and more than paid for itself in the rails manufactured for Government use, and after the close of the war was sold for $175,000.

TABULAR STATEMENT OF OPERATIONS.

The following table presents in a condensed form the amount and cost of work done by the Construction Corps on the roads named. Nearly the whole of this work was done in 1864, and its performance was substantially a part of the Atlanta campaign.

At the close of the war the Government turned over all the military railways to their former owners:

Cost of Materials used and Labor performed for Construction and Maintenance of Way on the U. S. Military Railways in the Military Division of the Mississippi.

NAME OF ROAD.	From	To	Length. Miles.	Bridges built by Govern't, R. Iles.	TRACK. Miles laid by Government.				COST.			
					Main tr'k.	Sidings.	Total.		Materials.	Labor.	Cont't Work.	Total.
Nashville and Chattanooga	Nashville	Chattanooga	151	21,727	129 75-100	19	148 75-100		$1,747,741 00	$1,046,553 62	$385,216 71	$4,079,511 33
Shelbyville Branch	Wartrace	Shelbyville	9									
McMinnville and Manchester	Tullahoma	McMinnville	35									
Nashville and Decatur	Nashville	Decatur Junction	120	24,275	31 50-100	2 65-100	34 15-100		416,480 00	662,835 91	549,326 13	1,658,642 04
Mt. Pleasant Branch	Columbia	Mt. Pleasant	12									
Memphis and Charleston	Stevenson	Decatur Junction	80	4,943	3 50-100	1 07-100	4 57-100		75,685 00	296,308 18	88,442 33	380,435 51
Chattanooga and Knoxville	Chattanooga	Knoxville	112	4,002	35	3 38-100	38 38-100		542,050 50	500,594 45	161,990 26	1,210,575 21
Cleveland and Dalton Branch	Cleveland	Dalton	27									
Nashville and Northwestern	Nashville	Johnsonville	78	21,320	46 50-100	4 25-100	50 75-100		489,779 12	798,829 73	182,789 11	1,471,397 96
Chattanooga and Atlanta	Chattanooga	Atlanta	136	13,676	130 75-100	10 75-100	141 50-100		1,377,145 00	1,150,746 66	41,427 63	2,569,318 69
Rome Branch	Kingston	Rome	17									
Atlanta and Macon	Atlanta	Rough and Ready	11									
Nashville and Clarksville	Nashville	Clarksville	62	3,433	1 62-100	13	1 75-100		18,210 00	148,455 92		166,665 92
Knoxville and Bristol	Knoxville	Bristol	110	4,168	12 50-100	1 69-100	13 69-100		156,580 00	195,321 24		351,901 24
Rogersville Branch	Junction	Rogersville	12									
Memphis and Charleston	Memphis	Pocahontas	75						134,194 00	72,893 12		207,087 89
Mississippi Central	Grand Junction	Tallahatchie	48									
Mobile and Ohio	Columbus, Ken'y	Crockett, Tenn	35						3,702 00	16,582 88		20,345 32
Louisville City	River Landing	L. & N. R. Depot	2									
Totals			1,132	*97,544	391 12-100	42 32-100	433 44-100		$4,961,607 83	$5,745,081 11	$1,409,192 17	$12,116,881 11

*18 47-100 miles.

IRON AND STEEL NOTES.

SCOTCH IRON MANUFACTURE.—Prof. Thurston, U.S., has lately been criticising rather sharply the Scotch practice of reducing iron ore. The great wastefulness of fuel, and the small amount of iron produced as compared with other districts, form the groundwork of his remarks. He states the number of furnaces in blast to be 127, and the production of the larger furnaces rarely exceeds 200 tons weekly, though the principal ore is the Scotch blackband, which contains 60 per cent. of iron after calcining. The roasting is often effected without much expense for fuel, the carbon contained in the ore being sufficient—4 to 10 per cent. is the usual quantity added. The calcined ore is charged into the furnace with from 20 to 30 per cent. of limestone, making about 2 tons of these materials per ton of iron. The proportion of fuel used there is, however, extravagant, averaging, as it does, between 45 cwt. and 50 cwt. per ton of iron, and to this has to be added the amount of slack required for steam and heating the blast. But his extremest surprise is raised at finding that the countrymen of Neilson either do not appreciate the full value of his discovery, or are unable to avail themselves of it, the heat from the blast rarely exceeding 700 deg., and its pressure upon the average furnace being about 3 lbs. to the sq. in. The extreme cheapness of fuel may have had its influence in producing the marked difference between the Scotch and Cleveland practice, but it is high time that the increasing expense of Scotch ores and the competition of other districts should cure anything like slovenliness in a manufacture of so much national importance. The product of the Scotch furnaces is usually of the well-known dark foundry grades, the phosphorus it contains giving it fluidity and easy fusibility. The lighter grades by careful puddling are made into fair wrought iron, as the Clyde yards can testify. The immense and rapid growth of the manufacture of steel by the pneumatic process has caused a corresponding demand for ores of exceptional purity, as it is impossible to work this process if the phosphorus attains 1 per cent.; hence it is that the Cumberland iron is so much in demand as to be beyond the producing power of the furnaces. Those ores are almost the ones turning out iron pure enough for the process. If all other districts devote their best skill to the treatment of the ores they have to do with, even phosphorus may be, perhaps, eliminated, now that it is known to be so detrimental.—*Mining Journal.*

PHOSPHORUS IN IRON AND STEEL.—A method of determining the amount of phosphorus in iron and steel is thus stated by Prof. C. A. Joy, in the "Journal of Applied Chemistry":

In the proceedings of the Chemical Society of Berlin, we find a method of analysis of iron proposed by F. Kessler, which appears to be easy of execution, and to afford accurate results. The process is briefly as follows: 5.6 grains of the substance are digested with nitric acid, evaporated to dryness, strongly ignited, dissolved in hydrochloric acid, reduced with sulphuretted hydrogen gas, treated with a solution of 42 grms. of ferrocyanide of potassium, the whole diluted to 518 cubic centimetres instead of 500, allowing 18 c. c. for the volume of the precipitate; 250 cubic centimetres of the filtrate from the above are measured off, and sulphate of magnesia and aqua am-

monia added to precipitate the phosphorus, which is afterwards determined as pyro-phosphate of magnesia in the usual way; 1 decigram of the magnesium phosphate indicates 1 per cent. phosphorus in the iron.

The author prepared a series of test mixtures of known constitution, varying from 1 per cent. to 0.020 per cent. phosphorus, in order to prove the accuracy of the method, and gives the following table of results:

Known composition.	New method.	Old method with molybdic acid.
1.000	0.990	1.005
0.100	0.105	0.110
0.050	0.025	0.021

Three samples of iron were analyzed according to the old and new process. A. soft cast iron; B. white cast iron with 12.5 per cent. manganese; C, steel. Phosphorus obtained:

	A	B	C
According to new method..	1.052	0.185	0.045
With molybdic acid.....	1.020	0.185	0.030

As Kessler's method enables us to dispense with the highly expensive molybdic acid, and appears to give accurate results, there would appear to be no objection to its general adoption. A ready way of determining phosphorus in ores has become of great importance since the introduction of the Bessemer process, and the above treatment may supply the want that has been felt by our ironmasters.—*Railway Times.*

PATENT HEATING FURNACE AT THE ROUND OAK WORKS.—The agent for the Earl of Dudley, at the Round Oak Iron Works, Staffordshire, has lately been testing a heating furnace, patented by Mr. Andrew Howatson, late of Messrs. Baird's works, Muirkirk, Ayrshire, in the 12 in. mill. The process consists of introducing heated air instead of cold air, as formerly, into the ash-hole. The air is heated by its being allowed to pass round the bottom of the stack, and under, and at the back of the furnace itself. It is supposed that the air is by this means heated to a temperature of 600 deg. The back of the ash hole and the firing hole are securely fastened up by air-tight doors, so that no cold air whatever is allowed to pass into the furnace. The consequence of this is, that the iron is not "cut away," or wasted through raw air entering through the firing hole and bridge. The results so far have been satisfactory. Tests have been made—the iron and coal being weighed into this furnace, and to one on the ordinary principle facing it, both furnaces being previously put in first-class repair. In two "turns" working, a saving was shown of 4 cwt. 1 qr. 23 lbs. weight of iron; the total of coal saved was about 14 cwt; and 9 cwt. 2 qrs. 23 lbs. less of cinder were made in the two "turns" working under the new process—proving a saving in iron and brickwork, etc. The furnace has now been at work nine weeks, and has not had any repairs done to it beyond a new bridge; and the proprietors and managers are so satisfied with it that they are putting down another in their 8 in. mill.

COST OF MAKING MISSOURI IRON.—A writer in the "St. Louis Democrat" states that during the past year the average cost per ton of making iron at Carondelet has been as follows: 2¼ tons of coal, at $4.35 per ton; 27 bushels of Connellsville coke, at 18 cents per bushel. This reduced to raw coal would make 3½ tons, at $4.35 per ton. Iron Mountain ore, 1¾ tons, at $5.50 per ton. To this add labor, $4.31, interest $1.14, expenses $1.50, limestone 27 cents, and we have a total of $31.71 as the cost per ton of all pig metal made at Carondelet. This cost of making iron, the writer says, leaves no margin for the capital invested, or the very great uncertainties of a blast furnace. It shows, that, while the labor and interest accounts are small comparatively, the fuel and ore cost more than three-fourths. He goes on to say further: "In Missouri, we pay 2½ cents per ton per mile for transporting iron ore, while in Pennsylvania it costs only 1 cent per ton per mile. There is a monopoly at present of iron ore and fuel, but the railroads now being built will place the iron men in a condition to bring competition to bear on this matter."—*Am. Railway Times.*

THE BESSEMER STEEL WORKS of the Chicago Union Rolling Mill Company commenced operations on the 28th ult. The steel works building is 336 by 124 ft., erected at a cost of about $300,000. The pig iron used is made by the Company at Knightsville, Ind., from a mixture of Missouri and Lake Superior ores. We understand the Company has orders on hand for all the steel rails that can be turned out this year.

IN that portion of France that has just been annexed to Germany, there are 200 blast furnaces and 160 puddling furnaces; their production of rails and iron of every kind amounts to about 140,000 tons per annum. Other French groups will, probably, make good the deficiency thus occasioned in the national production of France. The Nord will manufacture rails, the Muerthe will produce pig, the Haute Marne, rails and pig, and the Ardennes, manufactured iron.

RAILWAY NOTES.

THE TRANS-CONTINENTAL TRIP.—We took advantage during the month of August of the opportunities offered for making the great American tour across the continent. We followed first those lines of travel which lead most centrally through the States which lay on the route. From New York we went by way of the New Jersey Central directly across to Easton, and from thence by a route under the same excellent management, by way of Allentown to Harrisburg, Pa. The Pennsylvania Railroad bore us to Pittsburg, and the Pittsburg, Fort Wayne and Chicago delivered us safely at the great metropolis of the West in 33 hours from New York.

The attractions which this route possesses for the tourist who is bent on observation are numerous. The scene is never dull. First is presented the most thriving portion of New Jersey: pleasant villages, whose prosperity is mostly due to a liberal railroad policy; a picturesque, undulating surface, with frequent woodlands, whose delightful variety of foliage is not to be matched on any other portion of the whole route to the Pacific; frequent streams of clear water, indicating a region of abundant rains; well-made roads, and on nearing the west border, evidences of iron mining and manufacture.

The passage of the Delaware affords such an ex-

hibition of iron bridges of the rectangular truss variety, that the fine view to the south is apt to be passed without notice.

The Lehigh valley and its busy blast furnaces, the pleasant towns of Bethlehem and Allentown, the broader slopes and larger cultivated areas of the Keystone State, are the noticeable features of the line to Harrisburg.

From this point the route over the Alleghanies is full of the picturesque. Going west we passed the summit in the night, but on returning, although we had been revelling in the glories of the Yosemite by sunlight and moonlight, we experienced a fresh pleasure in the glimpses of wooded mountain scenery afforded on the east slope of the mountains. The "observation car" is just as desirable here as in Weber Cañon or the passage of the Sierra Nevada.

Ohio and Indiana are cut quite centrally by the route through Fort Wayne. The section was once the Far west, and was a marvel of productiveness to the New Englander. The traveller will not fail to notice the changes in the physical features; the absence of rocks or gravelly soil; less variety of forest trees; increasing flatness of surface as he goes west; a scarcity of streams, and the few he sees are muddy and slow; and at last, the true prairie.

In nearing Chicago, the river region of the Ohio and Mississippi is left, and the traveller, without passing a ridge or any conformation that bears the appearance of a divide, enters the hydrographic region of the great lakes and their outlet, the St. Lawrence.

The chief attractions of Chicago need not be enumerated here, two or three days may be profitably spent in and about the city. The engineering works have now a world-wide reputation. The last one, without being a great work, is a novelty, and a funny one at that. The Chicago River, which formerly emptied in the orthodox way into the lake, has been reversed; its mouth has become its source, and it now flows, bearing the waters of the lake and the rinsings of this enterprising city, through its former head into the Mississippi River.

From Chicago through Burlington and Quincy, and thence to Kansas City, we found abundant verification of the current accounts of the fertility and abundant mineral resources of Illinois and Missouri.

The bridges of both crossings of the great rivers have been fully described in our columns. The Eastern tourist may share in the pride of the Western resident if he be only an American, for they are essentially American works. In testimony of the smoothness of this portion of the road we may state, that a choir was extemporized in the Pullman car through the efforts of the conductor, aided by a fine parlor organ, which formed a part of the equipment of the car, and that through the afternoon ride familiar songs were sung by people throughout the car, as undisturbed by the common turmoil of travel as though they were in a drawing room.

Kansas City is in such an actively growing condition, that one feels at the first glance that it has increased somewhat since yesterday and will grow sensibly before to-morrow. It is geographically a Missouri town, but the whole West and Southwest may some day claim a right to be proud of it.

Beyond the great rivers one may claim to be in the Great West. The Kansas Pacific Railway, starting from this point, leads along the wonderfully fertile valley of the Kansas River, through a section singularly rich in such resources as the new settler finds most desirable. The corn of the valleys seemed more like a forest than an agricultural crop. The green slopes of the gentle undulations were only less fertile than the river bottoms. Stone, so useful in all kinds of structures, lies in beds *above* the level of the plains, as if designedly stored so as to facilitate quarrying and transportation.

The increase of elevation is quite gradual, but the ascent to the great backbone of the continent begins at the Missouri River, and at the westerly boundary of Kansas the railroad has an elevation of 4,000 ft. The plain, or plateau rather, is drier at this high elevation, and the buffalo grass grows sparsely. At the elevation of 1700 to 1800 ft., the herds of cattle, and for long distances, immense herds of buffalo, testified to the nutritious qualities of the short dry-looking grass.

Before reaching Denver the great wall of mountain to the west plainly indicates an entire change of surface configuration.

Denver, although something more than 5,000 ft. above the sea, is without doubt well located, and is destined to become an important, if not a great city. The rainfall is not abundant, but a supply of water is readily obtained by carefully utilizing the springs and streams from the near mountains. The city is growing with great rapidity. The narrow-gauge question is being practically tested by a road of 3 ft. gauge already running its construction trains. Rolling stock of all kinds was on the tracks ready for the regular routine work of daily traffic. Many more such roads will doubtless radiate from the same centre to the mining localities for which Denver will always serve as a principal base of supplies. Aside from its commercial importance, however, Denver is already an important objective point for the tourist; lying between, and on the only route joining the buffalo plains and the Rocky Mountain Parks, it is the gathering place of sportsmen as well as pleasure tourists.

The Kansas Pacific Railway, of which we take leave at Denver, seems, to such inspection as we could make, a model of good management; its termini are the two most rapidly growing cities of the West; and, aided by the mining and agricultural resources of the sections within its reach, its future continued success seems certain.

The Denver Pacific Railway, 100 miles in length, connects the western terminus of the Kansas Pacific with the Union Pacific Railway. It runs approximately parallel with the mountains. The experimental town of Greeley is the one point of interest on the route. An attempt is being made to cultivate the high plains here by aid of irrigation from the mountain streams.

The present success affords the highest encouragement for the future.

It will be of great service to the mining region if successful agriculture becomes an accomplished fact at Greeley.

Cheyenne is the junction of the great lines of travel. There is nothing to be said of the town at present, and we discover no signs of growth.

From Cheyenne west the Union Pacific road rapidly rises to the highest railway station in the world, Sherman, 8,242 ft. above the sea. For 450 miles the line of the road is more than 6,100 ft. high. This is the great plateau of North America.

The Rocky Mountains are barely visible when crossing the culminating point. Much of the region bordering on the road is quite flat, and in many places where water has been obtained, quite fertile. Laramie Plains afford good crops. Corn, clover, and fruit trees were flourishing at Humboldt; where springs in the mountain near at hand had been conducted by pipe distribution to the fields near the station. The experiment is capable of repetition, without doubt, in many more places where now nothing grows but sage bush.

The mountains crowd upon the road as it descends from the high plateau to the basin of Utah. The scenery for several miles is exceedingly wild. The rocks, sometimes massive, and occasionally exhibiting slender and grotesque forms, afford abundant opportunities for the enjoyment of the picturesque. The railway management have thoughtfully supplied an open observation car for the accommodation of passengers through this portion of the route.

At Ogden begins the Central Pacific Railway. It is also the northern terminus of the Utah Central Railway; the principal importance of which is, that it affords an easy access for modern civilization to the great centre of Mormonism. He who would see Salt Lake City as it was under strict Mormon rule, must go soon.

At Ogden begins the Central Pacific Railroad. It traverses for several hundred miles the great central basin of the continent. The rivers have no outlet; the rainfall is exceedingly scanty, and to the eye of the casual observer there is no promise throughout the *desert* of any agricultural product. The fact of the rivers, however, suggests a possible irrigation when near enough to the mountains; and such towns as Salt Lake City, Ogden, and Corrinne, prove the possibility of raising many kinds of food crops in fair abundance. At present, however, the mining interests are the most important on the line of the road throughout Utah and Nevada. The student of Physical Geography or Geology must regard this desert with intense interest.

The road is well built, and is kept in an excellent state of repair.

The passage of the the Sierra Nevada exhibits some fine railway engineering.

The location of this portion of the route must have required unusual skill. The observation car is called into requisition here, and the occupants are invariably thrilled with the sight of the frightful precipices along the edge of which the car glides in its descent of the mountains.

The gold mining operations here are quite active on both sides of the road for many miles. The operation of hydraulic mining may usually be witnessed by the passengers on the train, but in our passage through the section it was the driest month in the driest of years, and the streams had refused their supply.

Sacramento is reached in 6¼ hours from the highest point in the Sierras. This city is worthy a longer visit than we could give it. In our estimation, the look of substantial prosperity which it presents throughout affords a more just cause of pride in American pluck and enterprise than any other city of the States. It is to be remembered that its present prosperity was assured while it was *not* on a highway of commerce, but that the same persistence and energy that built the city bent the national highway to its borders, and then directed it over the mountains by a path which American engineers will always regard with just pride.

The proper thing for the tourist to do when in Sacramento is to make his preparations for the Yosemite trip. If economy of time is regarded, this offset from the line of travel had better be made here or Stockton than at the terminus, San Francisco.

The traveller needs only one bit of advice and information not given in the printed circulars: that is, to take the least possible baggage into the valley. The so-called roads and trails leading into it are not the results of invention or manufacture in any sense, but only of discovery. To accept the term *road* as applicable to such trails as our stage driver conducted us over, is to make a large concession in scientific nomenclature.

The grandeur of the Yosemite is indescribable. It is a specimen of Nature's engineering, so vast as well as so unique that it seems to offer no suggestion to human invention. Another year it will be more accessible to tourists. The Central Pacific Railway will push its branch so far eastward this fall, that the stage ride will be materially lessened. It requires now about 8 days as a minimum in which to do the Yosemite, counting from the first departure from the Central Pacific at Lathrop to the re-arrival at the same point. San Francisco is reached in 4 hours more, and the trans-continental journey is completed. To be theoretically exact in the matter, we embraced an early opportunity offered us and indulged in a ride to Cliff House, whose balconies overhang the Pacific Ocean; thence along the beach 2 or 3 miles, and we again turned our faces homeward.

Under the guidance of the former Surveyor-General, Hon. J. Franklin Houghton, we were able to see much of the city that otherwise would unavoidably have been omitted.

We could not stay to sound the depths of the proffered hospitality of Californian friends. We can only say that the kind offers were such as are known to be characteristic of this great Western State, and seem somehow prompted by its immense resources.

Seated again by the window of a "silver palace car" we watched the panorama of the continent as it turned backward. California, Nevada, Utah, Wyoming, were produced successively without any hitch in the machinery. At Cheyenne we deviated from our westward route and continued on the line of the Union Pacific Railroad to its terminus, Omaha.

Through Nebraska the line follows the valley of the Platte, and the gradually increasing fertility as the eastern border is approached, makes an agreeable picture after the sterility of the desert. At Omaha the richness and productive power of the soil seem to culminate; high ground and low seem equally good.

The city itself offers the advantages of the most advanced enlightenment. The choicest spot in the city is occupied by the High School Building, a structure that we should find it difficult to match in our Eastern cities.

In continuing eastward, the smoothness and rapidity of our transit was such, that we took our breakfast in Iowa, dinner in Illinois, supper in Indiana, breakfast next day in Ohio, and dinner in Pennsylvania.

From the Pacific to the Atlantic we arrived at every station "oh time," or so near it, that the difference was not noticeable.—[Ed.]

As the prosperity of the iron trade of the country depends so largely upon the development of our railroad system, the following facts from "Poors' Railroad Manual" for 1871, will be interesting, particularly as they come from a source so reliable and intelligent:

"The railroad first constructed in the United States was the Baltimore and Ohio, of which 23 miles were opened for use in 1830. It was for two years thereafter worked by horse-power. The following statement will show the number of miles opened each year since the date:

Year.	Miles in Operation.	Annual Inc. of Mileage.
1830	23	....
1831	95	72
1832	229	134
1833	380	151
1834	633	253
1835	1,098	265
1836	1,273	175
1837	1,497	224
1838	1,913	416
1839	2,302	389
1840	2,818	515
1841	3,525	717
1842	4,026	491
1843	4,185	159
1844	4,377	192
1845	4,633	256
1846	4,939	297
1847	5,599	669
1848	5,996	397
1849	7,365	1,369
1850	9,021	1,656
1851	10,982	1,961
1852	12,908	1,926
1853	15,360	2,452
1854	16,720	1,360
1855	18,374	1,654
1856	22,017	3,643
1857	24,508	2,491
1858	26,968	2,460
1859	28,789	1,821
1860	30,635	1,846
1861	31,256	621
1862	32,120	864
1863	33,170	1,050
1864	33,908	738
1865	35,185	1,277
1866	37,017	1,832
1867	39,244	2,227
1868	42,277	3,033
1869	47,254	4,999
1870	53,399	6,145

"The number of miles constructed in the decade ending in 1840, was 3,513; in that ending with 1850, 5,508; in that ending with 1860, 21,614; and in that ending with 1870, 22,764. The greatest number of miles constructed in any one year, was in that just passed, in which 6,145 miles were opened. The mileage constructed in 1869 and 1870 equalled 11,144 miles. The progress of railroads, as will be seen by reference to accompanying tables, was seriously interrupted by the war of secession. During the four years of its continuance only 3,273 miles were opened—2,872 miles less than were opened during the past year. In that period only a very small extent of mileage was constructed in the Southern States. Within the past two years, great progress has been made in these works in that section of country.

"Of the ultimate extent of railway mileage to be constructed in this country no safe estimate can be made. It is likely to increase very rapidly for many years to come. The progress made will depend largely upon the amount of increase of our population; but as the same number of people double their traffic to these works every ten years, railroads will, for a long time, make rapid progress even in those States whose population is comparatively stationary. The State of Massachusetts has one mile of railroad to 5.27 square miles of territory. A similar ratio would give to the States of New York and Pennsylvania 9,000 miles of line respectively, or more than twice their present mileage. It would give to the state of Illinois nearly 11,000 miles, or two and a half times its present mileage. In each of these States, the construction of railroads will proceed rapidly till the ratio of Massachusetts is reached. The same may be said of other States having, in the aggregate, an area of 500,000 square miles. When a mileage of 100,000 miles is reached, the same necessity will be felt for the continued construction of these works that now exists.—*Bulletin of the American Iron & Steel Association.*

Brazilian Railways.—The railways and tramways already constructed in Brazil have an extent of 812,777 kilometres, exclusive of the Pará and Alagoas tramways, namely:

D. Pedro II	260,480 kil.
Valença branch	25,000 "
Santos (S. Paulo)	139,600 "
Bahia	123,500 "
Recife and S. Francisco	124,900 "
Cantagallo	49,100 "
Mauá	17,500 "
Apupicos and Caxanga (Pern.)	8,755 "
Recife to Olinda (Pern.)	8,000 "
Botanical Gardens (Rio.)	13,123 "
S. Christovam	42,779 "

In Construction.

Dom Pedro II	160,000 kil.
Cantagallo	35,000 "
Gundiahy to Campina	43,000 "
" to Itú	69,000 "
Total, ready 812,777 kil. In construction	307,000 kil.

Besides this, about 1,500 kil. have been given in concession or are under survey.

The Pennsylvania Railroad Company.—Prominent among the gigantic corporations of the present day, and the still more stupendous ones whose embryotic buds are not yet quite unfolded to the public gaze, stands the Penn. R. R Co. Created originally for facilitating intercourse between the extremes of Pennsylvania, it has constructed from its eastern to its western terminus from Philadelphia to Pittsburg—one of the most thoroughly built, perfectly equipped, and admirably directed railways in the United States, if not in the world. Having its termini located on the navigable waters of the Delaware and the Ohio, and controlling many of the lateral roads, it has open to it the traffic of the world. Possessing such great carrying capacity that its local traffic could not adequately employ it, its managers, yielding to their natural business instincts, have stretched out new iron ligaments, uncontrolled by State boundaries, to

every quarter from which traffic could be gotten or created, to feed the trunk line. Thanks to this policy, it draws support through the absolute control of other roads, reaching to the great inland seas of the North; and, unhin ered by the "Father of Waters," which it taps at several points, it already reaches Omaha, and is perfecting its connections to secure the carrying trade of the vast cotton fields of the South. Finally, arrangements are in progress by which, if not thwarted by the law, its eastern terminus will be transferred to immediate proximity to the Atlantic Ocean, while the early future will witness this control extended to the Pacific.

It is thus that a road less than 400 miles in length, less than a quarter of a century old, through the vitality and energy of its manag rs, controls, operates, and renders tributary to itself other roads extending from the Atlantic to the Pacific Ocean, and from the northern lakes to the Gulf of Mexico.

An examination of the annual reports of this Co. shows something of its present and prospective strength. These reports for a series of years show the following results:

——	Liability.	Profits.
1862	$35,324,214	$4,942,753
1863	38,295,658	5,081.196
1864	43,520,336	4,020,019
1865	45,856,799	3,819,654
1866	44,251,596	3.578,741
1867	46,100,425	3,905,054
1868	54,143,745	5,289,339
1869	65,030,302	5,022,825
1870	73,097,215	6,012,991

NARROW-GAUGE (3 FT.) PASSENGER LOCOMOTIVE, BY THE BALDWIN LOCOMOTIVE WORKS, FOR THE DENVER & RIO GRANDE RAILWAY.—This locomotive, with two others for freight service, has just been completed at the Baldwin Locomotive Works, and by the time this meets the public eye will undoubtedly be at work on the pioneer narrow-gauge line in the United States. As this machine is entitled to the designation of the first narrow-gauge passenger locomotive built or operated in this country, a brief description of it will be of interest both to the railroad and general public.

Its dimensions are as follows:

Cylinders	9 in. diam.
Stroke of piston	16 in.
Diameter of driving wheels	40 in.
" " pony wheels	24 in.
Distance between centre of pony wheels and centre of front divers	5 ft. 8½ in.
Distance between driving-wheel centres	6 ft. 3 in.
Total wheel-base of engine	11 ft. 11½ in.
Rigid wheel-base (distance between driving-wheel centres)	6 ft. 3 in.
Capacity of tender	500 gal.
Diameter of tender wheels	24 in.
Distance between centres of tender wheels	6 ft.
Total wheel-base of engine and tender	26 ft. 5½ in.
Length of engine and tender over all	35 ft. 4 in.
Weight of tender empty	5,000 lbs.
Weight of engine in working order	25,300 lbs.
Weight of engine on drivers	20,500 lbs.
Weight of engine on each pair of drivers	10,250 lbs.
Weight of engine on pony wheels	4,800 lbs.
Height of smoke stack above rail	9 ft. 9 in.
Height of cab from foot-board to centre of ceiling	6 ft. 3 in.

It will be seen that the rigid wheel-base is given as 6 ft. 3 in., the distance between centres of driving wheels. This is due to the fact that the leading or pony wheels are fitted with a swing bolster and radius bar, allowing them to move laterally under the engine in passing curves. These wheels are also equalized with the front pair of drivers. By this arrangement, while the pony truck assists in guiding the engine on a curve and so relieves the front pair of drivers from the excessive wear of tires which would otherwise result, the rigid wheel-base is reduced so that the engine will pass curves of very short radii without difficulty. It is, in fact, only about ⅔ that of the 4-wheeled cars designed and built for the same road.

As much interest attaches to the subject of the speed practicable on narrow-gauge roads, we may remark that the proportions of this machine are such that it develops the same total travel of piston in going one mile as does a locomotive having 24 in. stroke of piston and driving-wheels 5 ft. in diameter. It is therefore apparent that equal, or nearly equal, speeds are possible with this engine as with the engine of the usual pattern on the full gauge *i. e.*, 24 in. stroke and 5 ft. drivers.

The plan of this engine gives somewhat more than ⅔ of the whole weight on the drivers, so utilizing it for adhesion. Its tractive power on a good rail, exclusive of the resistance of curves, is as follows:

On a level	512 gross tons.
On a grade of 40 ft. to the mile	161 " "
On a grade of 80 ft. to the mile	98 " "

From these figures should be deducted 17 gross tons, the weight of the engine and tender in working order, to get the total weight of cars and lading which can be drawn on a level or on the grades named.

The freight locomotives built for the same road have three pairs of drivers and a swing-bolster pony truck. Their cylinders are 1! in. diameter and 16 in. stroke; drivers, 36 in. The total weight of engine in working order is 33,500 lbs., of which about 29,000 lbs. are on the drivers. Being distributed to 3 pairs of wheels, the weight on each pair of drivers is a little less than 10,000 lbs., nearly the same result as with the passenger engine.

We hope to give a full description of the freight locomotive also at an early day. —*Railway Review.*

THE RHIGI RAILROAD.—This interesting mountain line, which, being only 4½ miles long in that space overcomes an elevation of 3,770 ft., was opened for traffic on the 22d of May last, a trial trip, with perfect success, having been made the day previous. The following description is from the Directors' account:

"The whole length of the railway from the above-mentioned Vitznau to the frontier of the Canton of Schwyz, at Staffelhohe, is 5¼ kilos, or 16,140 ft., the vertical height of the last-named place above the level of the lake being 1,113 metres. The run of the straight lines is 3,417 metres, and that of the curves 1,724 metres, the latter

having a radius of 189 metres. With the exception of a short horizontal slip of 45 metres at the Vitznau station, and one of 39 metres at Staffelhohe, the whole line consists of gradients, the maximum being 25 in 100, the minimum 6.6, and the average 22. In addition to the two terminal stations, it is proposed to make a water station, with sidings, to allow other trains to cross or pass at Freiberg, half-way up the mountain, another at Folsenthor, and a third at Kaltbad. The most remarkable objects of engineering work on the line are the cutting in the rock just above Vitznau, the tunnel at Schnurtobel, the bridge over the chasm at the same place, and the cutting at Eichberg. The rolling stock at present consists of 3 locomotives, which are differently constructed from those used on more level ground, inasmuch as they have upright boilers, and their driving axles are furnished with cog-wheels, which secure them a firm hold or grip on a cogged rail – 3 large passenger carriages, with accommodation for 54 persons each, and 2 smaller ones fitted with 30 seats each. The Company's capital of 1,220,000 francs, all paid up, was found insufficient to cover the total expenses, which have amounted to 1,501,897 francs; the excess, caused partly by an alteration and extension of the original plans and estimates, and partly owing to the difficulty of obtaining the needful number of skilled workmen, in consequence of the disturbed relations between the neighboring States of France and Germany, had, therefore, to be raised by a small loan on mortgage, to be repaid out of the receipts of the line in certain stipulated proportions according to the annual amount of the earnings." – *Railroad Gazette.*

AN UNDERGROUND RAILWAY.—Lancaster, Pa. is the first city in the United states to put an underground railway into practical operation. It is not so large as the Metropolitan of London, but serves its purpose, and is due to the energy of one manufacturer entirely. The railway in question is in a tunnel running between the cotton mills Nos. 2 and 3 of Mr. John Farnham, of Philadelphia, the sole proprietor of these mills. This tunnel connects the tower of mill No. 2 with that of No. 3, and runs under Prince street, a total distance of 180 ft. in length. It is intended to economize labor and expedite the transmission of goods from one mill to another. For this purpose a railroad is laid in the tunnel on which a platform car will be run. The tunnel, is arched with brick, is 7 ft. high and 6 ft. in width, and, as above stated, 180 ft. in length. A great convenience in the handling of goods will thus be afforded by a little engineering skill. The mills connected by this underground railway employ no less than 900 hands, including men, women and children.—*Iron Age.*

ORDNANCE AND NAVAL NOTES.

THE NAVY.—In consequence of the Agincourt having been saved from her perilous position, the Achilles and other ships which were ordered to proceed to her rescue have been recalled, and will return to their ordinary stations. The promptitude with which the Achilles got away from Portland proves the value of the present system of reserve. The Captain Committee stands adjourned for a fortnight from Thursday, when it will again meet, and no doubt shortly afterwards will conclude its labors. Dr. Minter, of the Royal yacht, has been nominated to succeed Deputy-Inspector of Hospitals and Fleets W. T. Domville, at Malta Hospital. We understand that Dr. Minter's appointment has been made at the request of the Court, and that the authorities now in office could not reasonably refuse to comply with a wish of the kind.—*Army and Navy Gazette.*

SHIPBUILDING has long been carried on in Belfast with varying success. Recently there were 3 iron ships on the stocks together, being constructed by the firm of Messrs. Harland & Wolff, successors to a previous firm, who were also much engaged in shipbuilding. Messrs. Harland & Wolff gave employment to several hundred hands, and some of the screw steamers of the Royal Navy have been built by them. In a few years more, if shipbuilding does not decline as a British trade, Belfast will probably afford greater and fuller facilities for shipbuilding, from its increasing harbor improvements.

HER MAJESTY'S SHIP DEVASTATION.—This great turret frigate was formally launched at Portsmouth dockyard lately. The Devastation is the first of her class afloat as a sea-going monitor, carrying 35-ton guns, and clothed with thicknesses of 14, 12, and 10 in. armor, and is, therefore, looked upon as a triumph of the turret over the broadside principle of carrying guns of exceptionally large calibre at sea.

GREENOCK HARBOR.—The foundation-stone of a new graving dock was laid at Greenock a few days ago. The site of the undertaking has cost £80,000. The dock, with pumping machinery and caisson complete, will cost £50,000, and the temporary and outer works £18,000. The contract is expected to be completed by the spring of next year. As showing the rapid increase of the shipping traffic at this port, it may be stated that the harbor revenue in 1836 was £11,637; in 1861, £25,000; and this year was estimated to be £53,000.

THE GERMAN NAVY.—Great additions to the strength of the German fleet are contemplated. Besides the 3 turret-ships, 2 of which are to be built at the Royal Docks at Kiel, and 1 probably by the Stettin Company Vulcan, 7 corvettes are to be constructed at the Royal Dockyard of Dantzic. Four of these are to be of the size of the Ariadne, and 2 of that of the Alabatross. The seventh corvette, to be built at Dantzic, is the Louise.

TURKISH TORPEDOES.—About 300 torpedoes are said to be now sunk at the Black Sea mouth of the Bosphorus, and the strait is believed to be impassable by a hostile fleet.

ADMIRAL POTHUAU has ordered 4 steam despatch boats to be sent from Toulon to guard the coasts of New Caledonia.

IT IS said that Mr. Rowsell is to be placed at the head of the Store and Purchase Departments of the Navy, which it is believed will be shortly amalgamated.

INDIAN HARBORS.—Mr. Robertson, the marine engineer dispatched by the Duke of Argyll to examine the condition and capabilities of Indian harbors, has sent in his report on the following

places: Mangalore, Cannanore, Calicut, Beypore, Narakal, Cochin, Allepy, Quilon, Tuticorin, Negapatam, Porto Novo, and Coconada.

AFTER having undergone considerable repairs on the patent slip at Capetown the steamship Gambia became a total wreck in Algoa Bay.

ENGINEERING STRUCTURES.

BRAZILIAN TELEGRAPHS.—The Government telegraphic lines of Brazil have a total length of 2,080 kil. The longest line is the one between Rio de Janeiro and Porto Alegre, near the frontier of Uruguay.

The line betweeen Rio de Janeiro and Pernambuco is under construction, and will be 2,023 kil. long. Its cost is estimated at $164,000—$180,000 being for labor, and the rest for wire, etc. Posts of iron are to be used, as the wooden ones have proved a failure in Brazil. The Government telegraph service cost in 1870 $141,000, including outlay for material for repairs and extensions. The number of telegrams transmitted was 45,792. The receipts, $55,200.

THE "INTERNATIONAL" (BUFFALO) BRIDGE.—The Buffalo "Advertiser" gives the following graphic account of the immense difficulties encountered in this work:

"In spite of untiring and patient labor a succession of obstacles have been met that must seriously retard the work. By a sudden fall in the water level, owing to a strong wind off shore, the fifth caisson, which was being sunk in 45 ft. of water, settled to the bottom of the river, lowering about 12 in., and was forced by the current slightly out of proper position. The difficulty was not so great that any serious trouble was anticipated, and a rise of water would have placed the crib in such shape that the correct line could have been reached. But ill luck seems to attend the location of this crib, and the next day it was evident that the structure was getting badly out of line. The crib rested on a gravel bed, about 5 ft. in depth, and the strength of the current, even at the bottom of the rapidly moving river, was so great that the gravel was being sucked out from underneath. Nothing was to be done but to go over the task, discouraging as it might seem. The concrete filling of the crib will have to be removed, the structure again placed in line and sunk to a solid bottom. We do not know, but suppose that the bottom of the river at that point will have to be prepared for the reception of the structure. No one can fully appreciate the difficulty attending a work of so extensive a character without visiting the spot. Old Niagara rushes by with a 7-mile stride at the point where the bridge is to cross, and to oppose so powerful an agent as water, when compressed within bounds and driven by superhuman force, to say nothing of overcoming accidents from other sources, has proved a hard task indeed. When the structure is completed, and the United States and Canada shake hands over the noble stream that flows past our city, the work will stand as another proof of what mechanical skill and patient dint can accomplish."

THE DETROIT TUNNEL.—The Detroit "Post" states upon authority that work upon the river tunnel will be commenced at once. All the money required has been secured, and organizations have been effected on both sides of the river, which in due time will be consolidated. Mr. Cheesebrough, the engineer of the lake tunnel at Chicago, will have charge of the work.

The plan contemplates really a series of 3 cylindrical tunnels. Two of these will be for road purposes, each being 18½ ft. interior diameter. They will be parallel and 50 ft. apart. This plan is deemed preferable to a single tunnel with double tracks, both on account of less liability to accidents and delays, and on account of strength and economy. The 3d tunnel will only run under the river; will be below and midway between the others; is designed for drainage only, and will have an interior diameter of 5 ft. This 3d tunnel will be constructed first, in order to fully develop the character of the soil, and to drain the other 2 as the work progresses. It is expected that the building of the lower tunnel will fully determine the feasibility of the entire project, and this will, therefore, be completed before work is undertaken on the road tunnels proper. If difficulties are met with anywhere, the drainage tunnel will be likely to encounter them, and their nature can then be determined before any great expense is incurred.

Work will be first commenced on the grounds of the Det. & Mil. R. Co., near the foot of St. Antoine street. Here a shaft, 10 ft. in diameter, will be sunk, and excavating under the bed of the river will proceed from that point. As the excavating proceeds, a shell of brick masonry will be constructed in a permanent manner. By the time the middle of the river is reached, if the project still appears feasible, operations of a similar character will be commenced on the other side, and the work will proceed from both directions. The building of this experimental and drainage tunnel, it is expected, will not take more than 2 or 3 months, so we shall soon know whether the proposed tunnel is possible. On the successful completion of the first, work upon the others will be immediately begun and proceeded with, with all possible dispatch. The engineer estimates that 1½ or 2 years will be required to complete the work. Of course much depends upon the results ascertained in the experimental tunnel. If it shall appear that the larger tunnels can unquestionably be built without danger or delay, the work will be pushed with all possible dispatch, and probably completed within a year.

The entire length of the tunnel, not including the approaches, will be about 2 miles, and its estimated cost nearly $3,000,000. When completed it will be used by all roads entering the city.

NEW BOOKS.

MODEL DRAWING, Containing the Elementary Principles of Drawing from solid form, the Method of Shading, and Pattern for making Drawing Objects in Cardboard. By ELLIS A. DAVIDSON. London: Cassell, Petter & Galpin. For sale by Van Nostrand.

This is another little volume belonging to the series which Mr. E. A. Davidson has from time to time written, and which Messrs. Cassell, Petter & Galpin have published. The previous volumes we have noticed as they appeared, and the same favorable criticism awarded to the previous volumes may be extended also to this. It is specially

intended to accompany a series of models of different elementary forms, by the aid of which an almost infinite variety of lessons may be given to the student, and the book, which, however, may be equally well studied without the models aforesaid, and which, by the way, seem to be unnecessarily costly, contains also practical directions to the student for enabling him to construct models for himself out of cardboard. As with the previous books, the present is divided into a number of simple problems, each of which is progressive, and is fully and clearly demonstrated and worked out. The combination of cubes, cylinders, cones, etc., afford a most excellent means of instructing the pupil, not only in geometrical, but also in perspective drawing; and though Mr. Davidson's book is full of useful information, it but indicates a small proportion of what may be done by the aid of the models.

Mr. Davidson is a thoroughly good teacher; moreover, he is able to place his instructions clearly and plainly upon paper, and the youngest and most inexperienced of his students cannot fail to realize the full amount of benefit from this book. We recommend it to all would-be draughtsmen; its price, three shillings, places it within the reach of all, and, taken in conjunction with the rest of the series, cannot fail to be a most valuable addition to the student's library. We suppose it will be followed by others upon the projection of shadows, etc.

A Practical Treatise on Coignet Beton, and other Artificial Stone. By Q. A. Gillmore, Bvt. Maj.-Genl. U.S.A. New York: D. Van Nostrand.

The subject of artificial stone is of constantly increasing importance. The undoubted success of the Coignet-Béton in the hands of the French engineers and artists, has prompted a vast number of experiments upon mixtures of lime, cement, and sand, by would-be inventors, who have announced, after brief trials, an unqualified success. The record of the failures of incautious builders who have trusted to these empirics, is not a pleasant one.

It is particularly gratifying to get at this time, from the hand of a thoroughly practical engineer, a report of his own careful observation and experiment upon artificial stone. The treatise will be regarded, among American engineers, as of the highest known authority. The author's previous labors in a similar direction, have paved the way to such a reputation.

The present work treats of Coignet-Béton, Ransome's Silicious Concrete Stone, the Frear Artificial Stone, the American Building Block, the Sorel Artificial Stone, Portland Stone.

Numerous experiments upon tensile and crushing strength of these building stones are carefully tabulated.

Nine plates illustrate the first article, this being one of the series of professional papers submitted as reports to the War Department.

Gymnastic and Technical Education. By Francis H. Smith, A. M., Superintendent, and Prof Mathematics and Moral Philosophy in the Virginia Military Institute. New York: D. Van Nostrand.

This is a lecture delivered on the occasion of reopening the Institute for the Fall Session of the present year.

The lecturer dwells not upon the details of the curriculum, upon its desirableness. In the race for superior excellence among our technical schools, the Military Institute is doubtless destined to take a high stand, and it will do so chiefly through the labors of her able superintendent.

It was in this institution, we believe, that the idea was first projected of practical experimentation in general physics, as a systematic course of training.

Prof. Smith's pamphlet deserves many readers.

A Practical Treatise on the Condensation of Steam. By N. P. Burgh. London: E. and F. N. Spon. For sale by Van Nostrand.

The introduction to this work contains a history of the methods of condensation of steam from 1705 to 1838. Then follow 15 chapters descriptive of condensers for various kinds of engines, including locomotives. The two concluding chapters are devoted to general principles, and to rules and formulas.

Upwards of 200 engravings illustrate the work. Mr. Burgh's former works have already introduced him to the engineers of the country, and he needs no more favorable notice at our hands.

Spon's Dictionary of Engineering. London: E. and F. N. Spon.

This work is coming forward with satisfactory rapidity; the last number received probably finishes the articles under G.

The late numbers fully redeem the promise of completeness made in the beginning. The illustrations are most ample, and embrace the latest contributions to practical engineering.

The buyer can obtain the parts thus far published, in four octavo volumes, or in two, as he chooses. For sale by Van Nostrand.

Switches and Crossings. By Wm. Donaldson, C.E. London: E. and F. N. Spon.

This gives formulæ for lengths of switches, angles of crossings, and distances of crossing points, and heels of the switches from the springing of the curve.

The formulæ are expressed in algebraic terms only. Six plates illustrate the text. For sale by Van Nostrand.

A Treatise on Ventilation. By Lewis W. Leeds. New York: John Wiley and Son.

This is a course of lectures, delivered by the author before the Franklin Institute. The present work is an enlargement of the edition of 186 , containing about four times the amount of matter. Nothing could be clearer than the author's exposition of the principles and practice of both good and bad ventilation.

The pictorial illustrations are abundant, and, altogether, the work is the most complete and satisfactory of any we have seen devoted to this subject. For sale by Van Nostrand.

Modern Breech-loaders: Sporting and Military. By W. W. Greener. London: Cassell. For sale by Van Nostrand.

Mr. Greener is well known as a successful manufacturer of breech-loading sporting guns, and from the intimate knowledge of the subject possessed by himself and his late father, was well able to write a description of the various weapons known as breech-loading rifles. The book has no preten-

sions to any literary merit, but is a simple statement of the construction and capabilities of the various forms of breech-loaders, so many of which have sprung into life within the last 5 or 6 years. It also contains much useful information on revolvers, while the Gatling gun and the mitrailleuse, together with the various kinds of gunpowder, obtain their share of notice. At a time when we hear so many depreciatory statements of the Martini-Henry rifle, it is satisfactory to read the accounts of its performances which Mr. Greener has collected; and whatever may be invented in the future, we may rest assured that the troops of this country are, or will be, armed with as good a rifle as those of any other nation.—*Mechanics' Magazine.*

BRIDGES' GUNNER'S POCKET-BOOK. By Capt. T. W. BRIDGES, Royal Artillery. London, E. and F. N. Spon. For sale by Van Nostrand.

Nowadays nearly every profession has its special "pocket-book," and why not the artillerist? So thought Capt. Bridges; hence this little book, which originated in a few tablets he was in the habit of carrying in his pouch, and which, amended and enlarged, he has now published in a waistcoat-pocket form, consisting of more than 60 pages of useful information to the gunner, whether volunteer or regular. Here we find rules for finding the distance of hostile batteries, and tables giving the range of guns for various degrees of elevation; the drills for the different service guns, and various other items, from the rations for horses to the trumpet call for the soldiers' mess.—*Mechanics' Magazine.*

MISCELLANEOUS.

THE SPECIFIC GRAVITY OF OILS AND THEIR CO-EFFICIENT OF EXPANSION.—The sp. gr of oils as determined by oleometers is liable to inaccuracy from imperfect instruments. I am accustomed, in testing oils, to reject the use of the oleometer, and to determine the sp. gr. by finding the weight of a known volume of the oil, and calculating its sp gr. with reference to water at 15 deg. C. The sp. gr. varies very much with increase of temperature. In order to reduce the found sp. gr. to the sp. gr. at 15 deg., C., it is necessary to know the co-efficient of expansion of oil.

For the determination I use a 50 c.c flask.

It is necessary, first, to very carefully determine the weight of boiled distilled water which the flask contains at 15 deg C. This having been determined, we next find the weight of 50 c.c. of the oil under examination, and the temperature at which this is taken. Then, the weight of oil, divided by the weight of water at 15 dg. C, will give the sp. gr. of the oil at the observed temperature.

For example: 50 c.c. of castor-oil at 17.2 deg. C., equalled 47.6487 grammes. This divided by the weight of 50 c.c. of water at 15 deg. C. equalled .9654, that is, .9654 is the sp. gr. of the sample at 17.2 deg. C

The co-efficient of expansion is the difference in sp. gr. which corresponds to a difference in temperature of 1 deg. C.

Suppose the sp. gr. of an oil is determined at 15 deg. C., and is found to be .9162. The sp. gr. of the same oil determined at 20 deg. C. is .9131. The difference, .0031, corresponds to an increase of 5 deg. C.; that is, .00062 for 1 deg. C. In the same way the co-efficient of expansion is determined with sp. gr. taken at different temperatures and the average taken. I have made such determinations, and the following are the average results of a large number of trials:

Temp.		Co-ef. Exp.
14.4 deg. C. to	20 deg.	B = .000642
14.4 deg.	25 deg.	= 000641
15 0 deg.	20 deg.	= 000610
15.0 deg.	25 deg.	= .000625
	Average,	.000629

or, the co-efficient of expansion is .00063 for 1 deg. C.

The oil selected for this determination was pure virgin olive-oil.

In testing an oil by this method, it is best to make the determination at a temperature as near 15 deg. C. as possible.

We have then this rule: Multiply the difference between 15 deg. C. and x deg. C by .00063, and add or subtract the product to or from the sp. gr. previously obtained, according as the temperature is above or below 15 deg. C.

In the example above quoted, the sp. gr. of castor-oil is found to be .9654 at 17.2 deg. C. To refer this to 15 deg. C. we have: 17.2 deg. − 15 deg. = 2.2 × .00063 = .001386 ∴ .9654 + .0013 = .9667 = the sp. gr. at 15 deg. C.

To clean flasks, test-tubes, etc., which have contained oil, I use the following method: Let the oil drain off well; then put into the flask a little saponified red-oil; or better, melt a little palm-oil therein, and unite it with the oil by turning the flask around. The resulting mixture is very easily saponified by a hot caustic alkali. Every trace of oil can be removed by this treatment, which is far less expensive and troublesome than treatment with ether.

Commercial oils differ very much in sp. gr., although they may be classed under the same name. In the following table I give the results of my tests of the chief commercial oils. With but few exceptions, I procured the samples from first hands, and I believe them to be fair average samples of the oils sold in this city:

TABLE OF SP. GR. OF OILS.
CO-EF. OF EXP. = .00063 FOR 1 DEG. C.

	15 deg. C. 59 deg. F.
Sperm, bleached, winter	.8813
" natural, winter	.8815
Elaine	.9011
Red, saponified	.9016
Palm	.9046
Tallow	.9137
Neatsfoot	.9142
Rapeseed, white, winter	.9144
Olive, light greenish yellow	.9144
Olive, dark green	.9145
Peanut	.9154
Olive, virgin, very light yellow	.9163
Rapeseed, dark yellow	.9168
Olive, virgin, dark clear yellow	.9169
Lard, winter	.9175
Sea-elephant	.9199
Tanners' (cod)	.9205
Cottonseed, raw	.9224
Cottonseed, refined, yellow	.9230

Salad (cottonseed)	.9231
Labrador (cod)	.9237
Poppy	.9245
Seal, natural	.9246
Cocoanut	.9250
Whale, natural, winter	.9254
Whale, bleached, winter	.9258
Cod-liver, pure	.9270
Seal, racked	.9286
Cottonseed, white, winter	.9288
Straits (cod)	.9390
Menhaden, dark	.9292
Linseed, raw	.9299
Bank (cod)	.9320
Menhaden, light	.9325
Porgy	.9332
Linseed, boiled	.9411
Castor, pure cold-pressed	.9667
Rosin, third run	.9887

[*Mechanics Magazine.*

UNDERGROUND TEMPERATURE.—In a paper on this subject, read at the British Association, Prof. J. D. Everett said the intended boring at the bottom of Rosebridge Colliery had not been executed, recent occurrences in a neighboring pit having given the manager reason to fear an irruption of water in the event of such a boring being made. Careful observations of temperature have been taken by the engineers of the Alpine tunnel under Mont Frejus (commonly called the Mont Cenis tunnel). The highest temperature in the rocks excavated was found directly under the crest of the mountain, which is quite a mile overhead. This temperature was 85.1 deg. Fahr.; the mean annual temperature of the crest over it was estimated, from comparison with observed temperatures at both higher and lower levels (San Theodule and Turin), at 27.3 deg. Fahr. Assuming this estimate to be correct, the increase of temperature downwards is at the rate of 1 deg. in 93 ft., which, by applying a conjectural correction for the convexity of the surface, is reduced to about 1 deg. in 81 ft., as the corresponding rate under a level surface. This is about the rate at Dukinfield Colliery, and is much slower than the average rate observed elsewhere. The rocks are extremely uniform, highly metamorphosed, and inclined at a steep angle. They contain silica as a very large ingredient. They are not faulted to any great extent, and are very free from water. It is proposed to sink two bores, to the depth of from 50 to 100 ft. at the summit, and another point of the surface over the tunnel, with the view of removing the uncertainty which at present exists as to the surface temperature. Mr. G. J. Symons has repeated his observations at every fiftieth foot of depth in the water of the Kentish Town well, between the depth of 350 and 1,100 ft., the surface of the water being at the depth of about 210 ft. The observations which have been repeated, are thus completely free from the disturbing effect of seasonal changes.

The results obtained agree closely with those previously found, and show, between these depths, a rate of 1 deg. in 54 ft., which, from the estimated mean temperature of the surface of the ground, appears to be also very approximately the mean rate for the whole 1,100 ft. The soil from 325 to 910 ft. of depth consists mainly of chalk and marl, and shows a mean rate of 1 deg. in 56 ft. From 910 to 1,100 ft. it consists of sandy marl, sand, and clay, and shows a mean increase of 1 deg. in 54 ft. The former of these is in remarkably close agreement with very trustworthy determinations made by Walferdeu, from observations in the chalk of the Paris basin. These are as follows: Puits de Grenelle, Paris, depth 400 metres, rate 1 deg. Fahr. in 56.9 ft.; well at Military School, Paris, depth 172 metres, rate 1 deg. Fahr. in 56.2 ft.; well at St. André, 50 miles west of Paris, depth 293 metres, rate 1 deg Fahr. in 56.4 ft. General Helmersen, of the Mining College, St. Petersburg, informs the secretary, that in sinking a well to the depth of 540 ft. at Yakoutsk, in Siberia, the soil was found to be frozen probably to a depth of 700 ft. The rate of increase from 100 ft. to 540 ft. was 1 deg. Fahr. in 52 ft. A new pattern of thermometer has recently been constructed for the committee, which promises to be of great service. It is a maximum thermometer, on Negretti's principle, adapted to be used in a vertical position, with the bulb at the top. The contraction in the neck prevents mercury from passing into the stem when the instrument receives moderate concussions. Before taking a reading, the instrument must be gently inclined, so as to allow all the mercury in the stem to run together into one column near the neck. On restoring the thermometer to the erect position, the united column will flow to the other end of the tube (that is, the end furthest from the bulb), and it is from this end that the gradations begin. It is set for a fresh observation by holding it in the inverted position, and tapping it on the palm of the hand. This instrument, like that heretofore used by the committee, is protected against pressure by an outer case of glass, hermetically sealed. —*Mining Journal.*

TESTING BOILERS.—The telegraph states that Mr. F. B. Stevens, of the Camden and Amboy Railway, who has charge of the ferry boats of that line, commenced on Saturday last a series of experiments before a number of distinguished experts, upon rupturing boilers with hydrostatic pressure. The first experiment was one boiler which had been allowed, on a ferry boat, to carry 40 lbs. of steam. Under the test, it leaked at an old patch at 90 lbs. pressure, started the stay bolts at 100, and at 112 the experiment was discontinued. The second boiler experimented upon was also allowed to carry 40 lbs. Under hydrostatic pressure it gave out at 66. The third boiler, which had been allowed to carry 30 lbs. of steam, broke the brace over the crown sheet at 42 lbs., but without a leak at 60 lbs. Four of the brace rivets broke. The fourth boiler gave way at 75 lbs.; it had been allowed to carry 40 lbs. This concluded the day's experiments. Mr. Stevens intends to continue them, and finally explode the boilers by steam, as they are very little injured by hydrostatic test, and can be easily repaired. By this means, the value of hydrostatic pressure in testing boilers will be decided. —*Am. Railway Times.*

STRENGTH OF BUILDING MATERIAL.—Experiments are sometimes made in regard to the power of stones of different kinds to resist compression, by cutting 1 cubic in. of each, placing it between 2 steel plates, and charging it with increasing weight till crushed. For convenience' sake, this weight is applied by means of a lever, so as to obviate the necessity of actually handling the hundreds and thousands of pounds—one or more sliding weights on a strong beam being sufficient for these experi-

ments. The results are indicated in the following table, in which the number of pounds is that of which the substance could bear the pressure, while it was crushed by the addition of more:

Table of resistance of a cubic inch of divers building stones against crushing pressure.

Name of Stone.	Where used or wherefore.	Weight applied in pounds
Inferior pale brick	For filling walls	2,000
Common good brick	" partition walls	4,000
Hard brick	" floors	4,500
Pressed Phila. brick	" fronts of houses	5,000
Sandstone from Acquia Creek, strata laid vertical	Many public build'gs, Washington	5,500
Marble, Baltimore (large crystal)	House trimmings, Baltimore	8,000
Sandstone, Acquia Creek (strata laid horizontal)	Public buildings, Washington	8,300
Marble, Montgomery Co., Pa.	House fronts, door sills, etc., Philadelphia	8,900
Marble, Lymington (strata vertical)	National Washington Monument	9,100
Marble, same (strata horizontal)	National Washington Monument	10,100
Marble, Stockbridge	City Hall, New York City	10,400
Sandstone, Seneca	Smithsonian Instit'te, Washington	10,800
Marble, Lymington (large crystal)	National Washington Monument	11,100
Granite, Patapsco		11,200
Marble, Italian	Statuary	12,600
Marble, Baltimore (small crystal)		18,000
Marble, Lymington (small crystal)	Washington Monument	18,200
Marble, Hastings, N. Y.	University Building, New York	19,000
Gneiss, Palisades, near New York	Pavements	19,750
Marble, Lee, Mass.	House fronts, Boston, etc.	22,700
" East Chester	Post-Office, Washington	23,900
Granite, Dry Island, Me.	New Post-Office, N. Y., Extension of Treasury, Washington	24,000

—*Manufacturer and Builder.*

PICKING TOOLS.—Mr. Jackman, of Sheffield, has recently patented an invention the object of which is, by the adoption of suitable mechanical arrangements, to attach in an effectual manner picks axes, adzes, hoes, and other similar tools or instruments, to their handles in such a manner that they may be more readily secured to and detached therefrom than by any arrangements of construction heretofore known or used. A socket of malleable iron or other suitable material is provided for receiving the picking tool or blade; this socket is attached to a wooden handle in the usual manner. The picking tool or blade is made with a depression or protuberance which fits into, or upon, a corresponding part of the socket; or, if preferred, there may be a series of depressions or protuberances, so as to give the tool a firmer hold of the socket. The picking tool or blade is secured in the socket by means of a set-screw, the point of which acts upon a "gib," or separate piece, which distributes the pressure of screw over a considerable surface of the tool; the set screw is further secured against slackening by the introduction of one or more lock-nuts. The set-screw, gib, and lock-nuts are conveniently arranged in the shaft side of the tool, thus dispensing with all projections in the end or sides of the pick, which are objectionable. The advantages of this invention are, that the tools may be easily replaced when worn or damaged, that they may be readily and securely fixed in their proper position in the socket, so that the set-screw, being provided with lock-nuts, will not easily work loose; and, especially, that the "gib," or separate piece, will distribute the pressure of the set-screw over a considerable surface of the tool, thereby giving greater security against slackening.—*English Mechanic.*

REGISTERING APPARATUS FOR STEAM GAUGES.—This little apparatus, invented by Mr. Bernard Stangk, of Rouen, will be found to be very useful to every manufacturer using steam power; its object is to register with complete accuracy the variations of the pressure of steam as marked by the gauge. By this instrument the chief of a factory is able to know at any moment the variations in the power developed by the engines, and none of his employees can interfere with the registration. The apparatus is simple and easy of application. It consists of a closed glass box, being in communication with the handle of the ganges by means of a little rod, at the end of which is fixed a small box running freely in a slide, and which is provided with a pencil. Under this pencil there is a drum covered with a paper ruled with 24 horizontal lines, denoting the 24 hours of the day, and with 8 vertical ones corresponding with the divisions of the gauge. The drum is moved by clock work, and as the drum accomplishes its 24 revolutions in 24 hours, the pencil leaves on the paper a true registration of the different pressures of steam which have been indicated by the gauge, marked by lines more or less undulating. The variations of pressure are found by measuring the undulations on the vertical line, and by comparing these with the crossings on the horizontal ones, the time of occurrence is found. The little instrument serves also as a tell-tale as to when the fires were lighted, covered, or put out.

STONE CEMENT.—Hydrated silica combines much easier with bases than common quartz-sand (anhydrous silica). On this Prof. Boettger has based the employment of infusorial earth, a white pulverulent mass which occurs in various localities in Europe and in this country, in large masses as the binding ingredient of an excellent cement for stone-work. He mixes equal parts of infusorial earth and oxide of lead (litharge) with ½ the quantity of hydrate of calcia (freshly slacked lime) and linseed oil varnish to a homogeneous thick paste, and obtains a mass of extraordinarily great binding power, which after some time assumes the hardness of common sandstone. This cement is applicable in all cases where iron is to be fastened in stone, where artistic stone-work, such as fountains, vases, statuary, etc, is to be mended; in short, where small quantities of the binding material are required. For the more common uses of the mason and stonecutter, this cement is, of course, too dear to permit of extended application.

THE relative value of gold and silver in the days of the patriarch Abraham was 1 to 8; at the period B. C. 1000 it was 1 to 12; B. C. 500 it was 1 to 13; at the commencement of the Christian era it was 1 to 9; A. D. 500 it was 1 to 18; A. D. 1100 it was 1 to 8; A. D. 1400 it was 1 to 11; A. D. 1613 it was 1 to 15½; which latter ratio, with but slight variation, it has maintained to the present day.